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U.S. ENVIRONMENTAL PROTECTION AGENCY

Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
A	ampere(s)	
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps-2.22×10^{12} dpm
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	3.527×10^{-2} ounces= 2.205×10^{-3} pounds
Hz	herts	cycle per second
kVp	kilovolt peak	
m	meter(s)	39.4 inches
m^3	cubic meter(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
mi	mile(s)	
ml	milliliter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g
s	second	

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RADIATION DATA AND REPORTS

Volume 14, Number 6, June 1973

Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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U.S. ENVIRONMENTAL PROTECTION AGENCY

Robert W. Fri, Acting Administrator

Reports

Summary of Environmental Monitoring at Philadelphia, 1958–1971

J. E. Lieberman,[1] *R. D. Ice,*[2] *M. Green,*[3] *and R. McGrattan*[4]

The City of Philadelphia maintains an environmental radiation surveillance program for evaluating the environment of the Delaware Valley. The program has evolved from the initial goals of setting operational guides for the collection and analyses of data at sites of nuclear ship operations, through preoperational radiological data collection associated with the construction of the N.S. *Savannah*, through a nuclear weapons fallout evaluation, to the present objective of providing environmental surveillance of nuclear facilities.

A 13-year compilation of environmental data from the City of Philadelphia is presented. Included are gross alpha and gross beta results of raw and finished surface waters, gross beta results of air samples, and strontium-90 and iodine-131 quantities in pasteurized milk.

Environmental radiation surveillance at Philadelphia started in 1958 as a cooperative program for evaluating the Delaware River and bay. The surveillance program involved the United States Public Health Service (USPHS), the City of Philadelphia Health Department, New Jersey Health Department, Pennsylvania Health Department, Delaware Health Department, and the New York Shipbuilding Corporation (NYS).

Th City of Philadelphia is actively involved in environmental radiation surveillance. The program complements the Pennsylvania Health Department Program with funds and equipment, integrates the city-wide air pollution and water assays that involve radioactive elements, serves as an early warning indicator of radiological hazards, provides immediate expertise to city disaster coordinators and basic scientific data for health hazards and program evaluation.

The initial objective of the program was twofold. First, to establish operational guides for the collection and analysis of environmental samples in the general area of nuclear ship operating sites. The second objective was to provide preoperational radiological data for the construction and test area of the N.S. *Savannah*. The first objective resulted in a protocol for radiological surveys (*1*) used by USPHS at all U.S. ports visited by the N.S. *Savannah* from 1963 to 1965. The second objective was completed when the N.S. *Savannah* started sea trials in 1962.

New York Shipbuilding Corporation (now doing business as Merritt, Chapman and Scott) builders of the N.S. *Savannah*, initiated radiation environmental sampling of the Delaware River in July 1958 under the direction of Dr. H. Locke. In March 1959, the USPHS established seven river and tributary water sampling stations on the Delaware River and one station on the Schuylkill River. The Robert A. Taft Sanitary Engineering Center and the Technical Operations Branch, Southeastern Radiological Health Laboratory, analyzed the samples (*2–5*). Between 1962 and 1965, the surface water sampling program was expanded under the direction of the Engineer-

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ing Program at the Northeastern Radiological Health Laboratory (NERHL). In 1965, the cooperative program involving the USPHS was terminated.

Because of the increased concern for fallout from nuclear weapons tests, and because the initial objectives of the radiation surveillance program associated with the building of the nuclear ship *Savannah* were almost completed, the surveillance program was reoriented to an assessment of radioactive fallout in August 1961. In addition to gross beta and gamma measurements of surface water, gross beta and gross gamma measurements of air, gross beta measurement of precipitation, and gross beta measurement of process water were initiated.

With the abrupt ending of the nuclear weapons aerial test ban by the Soviet Union on September 1, 1961, the Philadelphia air sampling program was expanded from one to three stations during September. In October 1961, the program was expanded to the analyses of a composite milk sample for gross beta and iodine-131 radioactivity. Gross gamma counting of precipitation was initiated in November 1961. In January 1962, gross gamma analysis of surface water samples was added to the existing measurement of gross beta radioactivity.

The first indications of fallout appeared in air samples collected September 15, 1961. Daily beta and gamma radioactivity in air from August 1 through September 14 remained consistently below 1 pCi/m³. The largest quantity of radioactivity in air was recorded on September 16, 1961 and was 73.8 pCi/m³ of gross gamma radioactivity. The highest daily average of the three stations, also on September 16, was 63.4 pCi/m³ of gross beta and 132 pCi/m³ of gross gamma. Recent changes in radioactivity of air samples have been correlated to current Chinese and French bomb tests.

To bring the analytical procedures into conformity with those of the USPHS, the Philadelphia Health Department revised their analysis procedures for surface water samples in March 1965. Gross gamma analysis of surface water was discontinued and gross beta radioactivity was determined on the suspended and dissolved solid fractions of a water sample in place of the total solids analysis.

Gross gamma analysis of surface water was replaced as the early warning indicator of gamma activity in the environment by a radiochemical program for analyzing iodine-131 in milk. An assessment of strontium-90, strontium-89, barium-140, and lanthanide radioactivity was also initiated in March 1965 as part of the milk analyses.

Table 1. Radiation Environmental Surveillance Program, Philadelphia

Sample	Location	Frequency	Activity measured
Air	3200 Frankford Avenue [a]	Daily	Gross beta
	1501 E. Lycoming Street	Daily	Gross beta
	500 S. Broad Street	Daily	Gross beta
River water	Schuylkill River:		
	Queen Lane Filter Plant	Weekly	Suspended alpha and beta
			Dissolved alpha and beta
			on all river water samples
	Delaware River:		
	Torresdale Filter Plant Dock (T–1)[b],	Weekly	
	Torresdale composite (T–2)[b]		
	1/3 Northern Metals		
	1/3 Torresdale Filter Plant		
	1/3 Mouth of Poquessing Creek.		
	Lehigh Avenue [b]	Weekly	
	Wharton Street [b]	Weekly	
	Northeast Sewage Plant [b]	Weekly	
Tap water	500 S. Broad Street	Weekly	Gross alpha and gross beta
	1501 E. Lycoming Street	Weekly	Gross alpha and gross beta
Precipitation	1501 E. Lycoming Street	After each rain	Suspended alpha and beta
			Dissolved alpha and beta
Milk	Composite	Weekly	Strontium-90 [c]
			Iodine-131

[a] Discontinued October 1970.
[b] Collected from midchannel using city's boat, *Aquadelphia II*.
[c] If iodine levels are >10 pCi/liter, the milk is analyzed for strontium-89 and barium-140 and also is subjected to gamma spectroscopy.

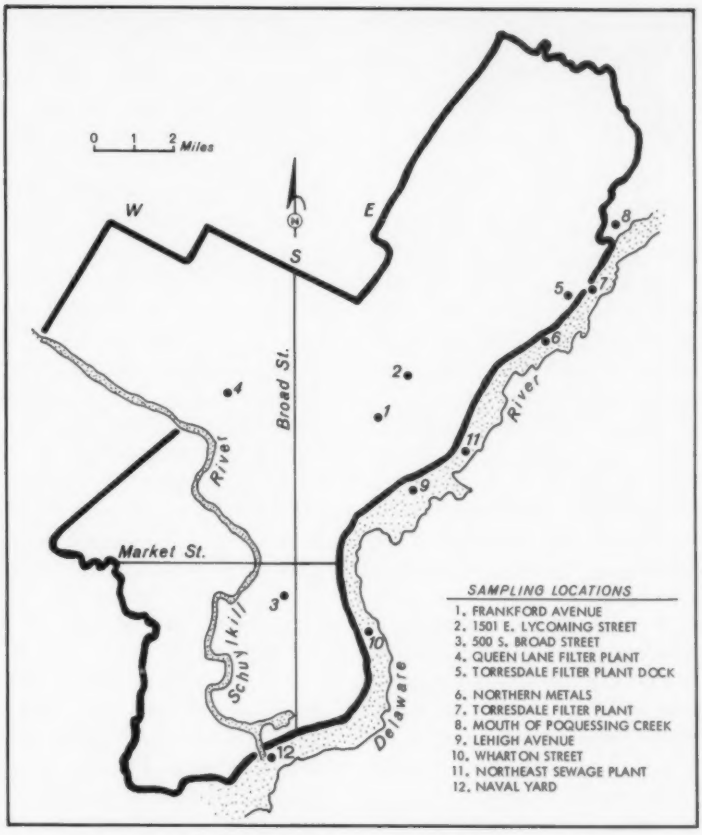

Figure 1. Sampling locations for Radiation Surveillance Environmental Program, Philadelphia

In 1965, the City of Philadelphia expanded its surface water sampling to include the sampling sites discontinued by the USPHS in the Delaware and Schuylkill Rivers. At present, the City of Philadelphia is monitoring raw surface water at four stations on the Delaware River and one station on the Schuylkill River plus a composite of Delaware River water.

The present City of Philadelphia Environmental Surveillance Program consists of the sampling stations and frequencies indicated in table 1. The location of sampling stations are indicated in figure 1.

The U.S. Geological Survey monitored tritium in the Delaware River at Philadelphia between 1964 and 1968 (*6*). The Delaware River has been assessed for gross radioactivity as part of the Water Pollution Surveillance System of the Public Health Service (*7*). The Philadelphia results (*7*) are presented in this report for comparison purposes.

In 1970, an ad hoc committee on radiation surveillance of the Delaware River Basin was formed to review the existing Delaware River Environmental Surveillance Program. The objectives of the committee were:

1. to review all accrued data and report the findings to the public,

2. to coordinate all surveillance within the Delaware Valley Basin minimizing duplication and to conserve resources, and

3. To reorient the existing program from a surveillance program, indicative of weapons testing, to a nuclear facility oriented surveillance program.

The City of Philadelphia, as the only major

city with an expanded environmental radiation surveillance program, is assisting in this regional approach to the evaluation of the environment. This report is a result of this interdisciplinary cooperative program.

Air monitoring

High volume air samplers provide daily filters for analysis of radioactivity in air. The Air Management Services Unit removed the filter from the air sampler. Samples were obtained from three locations (table 1). From an effective air filter area of 7¼- by 9 inches, two 1⅞-inch-diameter discs were removed and placed into 2-inch planchets. The planchets were identified by date and location and stored in a dessicator until counted in a Beckman Wide Beta Counter. All filters were counted for 10 minutes on day three or day five after collection to allow assaying of samples collected each day of the week during a 5-day work week. The counter efficiency was determined using a radium D and E sealed source. The minimum detectable activity (MDA) at the 95-percent confidence level was 0.007 pCi/m³. The minimum reported activity was 0.01 pCi/m³.

Prior to July 1966, a Baird Atomic GM Scaler Model 123 with a GM end-window tube (1.4–2.0 mg/cm² thickness) was used. Sample efficiency was determined using a calibrated bismuth-210 source, the minimum reported activity with the GM scaler was 0.3 pCi/m³.

Gross gamma measurements between August 1961 and July 1963 were made with a 3-inch NaI (Tl) scintillation detector. Counter efficiency was determined with a cesium-137 calibration source. The crystal had an average efficiency for cesium-137 of 28 percent. The results of air measurements are presented in table 2 and figure 2.

Water monitoring

The New York Shipbuilding Corporation sampled at three locations within the shipyard. Between July 1958 and December 1958, the sample results represent the average of daily samplings. Beginning in January 1959 through December 1965, results from weekly composite samples averaged for three locations were reported. Samples of 500 ml containing suspended and dissolved materials were evapoated under an infrared lamp onto planchets and counted for 1,000 counts using a GM counter having an end window thickness of 1.4 mg/cm².

From 1962 to 1965, the NERHL collected grab samples of river water at three stations in Camden, N.J. on a monthly basis. These samples were filtered to separate suspended solids and the suspended solids were counted for gross alpha and gross beta radioactivity. The results are presented in table 3. Sulfides and carbonates were precipitated from the filtrate and counted for gross alpha and gross

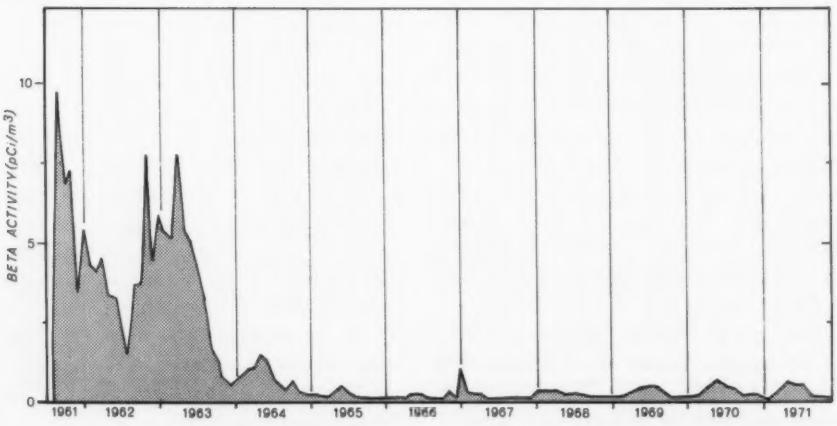

Figure 2. Gross beta radioactivity in air, Philadelphia, August 1961-December 1971

beta radioactivity.[5] The results are reported in table 3.

Between August 1961 and February 1965, the City of Philadelphia monitored gross beta and gross gamma radioactivity in the Delaware River and the Schuylkill River. Through December 1963, the reported results are the mean of 10 grab samples taken throughout the month. Beginning in January 1964, weekly grab samples were obtained, and the monthly results represent an average of four or five weekly analyses.

A 250 ml water sample was acidified with nitric acid, evaporated to 5 ml and counted in a 3-inch NaI(Tl) well counter. The count rate was compared to the efficiency of a cesium-137 standard well source. The 5 ml sample was then evaporated to dryness in a planchet and counted using a GM tube with a minimum detectable activity for beta radiation of 15 pCi/liter.

In March 1965, gross gamma counting of water samples was discontinued, and gross alpha analysis of suspended and dissolved solids was instituted.

In October 1965, additional weekly grab samples of raw river water at Wharton Street, Lehigh Street, and the Navy Yard were added to the environmental survey program. The Delaware River samples are collected by the city's boat, *Aquadelphia II*. All samples are taken from midchannel (average depth 35–40 feet) from a pipe extending 12 inches below the river's surface. Each sample of 500 ml was acidified with 1.5 N HCl and filtered through a Whatman No. 12 filter paper. The filter paper was dried and ignited in a muffle furnace for 2 hours at 550° C. and then cooled. The residue was transferred to a planchet, weighed and counted.

The filtrate was evaporated to 10 ml, gradually transferred to a planchet, and finally evaporated to dryness using an infrared lamp. The planchets were dried for 2 hours at 110° C. to constant weight and counted.

The samples were counted using a Nuclear Measurement Corporation model PC 3A proportional counter having a minimum detectable activity of 1.5 pCi/liter. The filtrate (dissolved solids) and residue (suspended solids) results are reported in table 3.

In August 1966, the laboratory began counting gross alpha and gross beta radioactivity using a Beckman Wide Beta II proportional counter. The minimum detectable beta activity with the procedures used was 1.0 pCi/liter. The minimum detectable alpha activity with the procedures used was 0.4 pCi/liter.

Precipitation and process water

The procedures used for precipitation and process water are the same as those used since 1966 with raw surface water. The precipitation and process water samples were obtained at 1501 E. Lycoming Avenue (table 4).

Milk analyses

A composite 1-gallon whole milk sample from dairies in the Delaware Valley is received weekly by the environmental radioassay laboratory. Immediately after collection of the milk sample, 1 liter is removed for iodine analysis and 3 ml of 37 percent formaldehyde solution per liter is added to the remainder for milk preservation. The remaining milk sample is stored for 2 weeks to allow ingrowth of yttrium-90 to equilibrium.

Iodine ion is separated from the milk using a Dowex 1-X8 anion exchange resin. The whole milk is passed through the anion exchange resin in a column and the resin transferred to counting tubes designed to fit within the 3-inch NaI (Tl) well crystal. The amount of iodine-131 is determined by counting the photopeak radioactivity using a differential count mode. The amount of radioactivity within the milk sample is compared to a known quantity of iodine-131 iodide ion that has been added to a second liter of milk, separated on the anion exchange resin and counted under the same conditions. The minimum detectable activity for iodine-131 under the counting conditions used was 10 pCi/liter. Based upon a practical reporting level, quantities less than 10 pCi/liter have been considered insignificant (*9*).

[5] Personal communication, James A. Hardin, Delaware River studies, radiochemical (January 12, 1971). Northeast Radiological Health Laboratory, Winchester, Mass.

Table 2. Gross beta radioactivity in surface air,[a] Philadelphia, August 1961 to December 1971

Sampling by station & year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1961												
Gross gamma average of all stations								0.4	18.2	7.9	11.2	4.2
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford								Started 9/6/61	8.7	6.0	6.4	3.6
City Hall Annex								Started 9/10/61	11.9	6.7	6.8	3.4
3200 Frankford, horizontal								.4	9.3	7.8	8.5	3.6
Air surveillance, all Philadelphia stations gross beta (pCi/m³):												
Maximum								.7	73.8	17.5	27.4	10.9
Minimum								<.1	<.1	1.5	2.0	.2
Average [b]								.4 (31)	9.9 (68)	7.2 (93)	7.3 (88)	3.5 (92)
1962												
Gross gamma average of all stations	6.9	5.2	4.9	5.3	3.8	3.7	3.0	1.8	5.1	5.5	11.1	5.7
Average gross beta radioactivity, per station (pCi/m³):												
3200 Frankford	5.6	4.9	4.2	4.8	3.5	3.3	2.6	1.5	3.9	3.4	9.0	4.3
City Hall Annex	5.6	4.1	4.1	4.3	3.3	3.4	2.6	1.4	3.2	3.5	7.1	4.3
3200 Frankford (horizontal)	5.7	4.3	4.1	4.6	3.4	3.3	2.6	1.4	4.0	4.3	7.4	4.7
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	10.1	11.2	8.9	8.6	6.5	6.9	5.2	3.1	12.7	12.0	33.5	11.7
Minimum	2.3	.3	.3	.6	.3	.1	.8	.2	.3	.2	.9	1.0
Average [b]	5.6 (89)	4.4 (83)	4.1 (90)	4.6 (90)	3.4 (91)	3.3 (88)	2.6 (91)	1.4 (91)	3.7 (87)	3.8 (93)	7.8 (83)	4.4 (76)
1963												
Gross gamma average of all stations	7.5	6.3	5.9	9.5	6.4	5.6	4.6					
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	6.2	5.1	4.7	7.5	5.6	5.0	4.2	3.2	1.7	1.4	.7	.6
City Hall Annex	5.5	5.8	5.2	7.2	5.1	5.0	4.2	3.2	1.9	1.3	(c)	—
3200 Frankford (horizontal)	6.2	5.5	5.5	8.6	5.8	5.1	4.1	3.2	1.8	1.3	.7	.5
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	12.7	9.5	12.2	22.9	14.0	10.4	8.5	6.6	3.7	2.2	2.1	1.1
Minimum	.4	2.2	1.6	1.2	1.4	.6	1.4	.6	.2	.4	<.1	<.1
Average [b]	5.9 (89)	5.5 (75)	5.1 (89)	7.8 (89)	5.5 (91)	5.0 (90)	4.2 (93)	3.2 (91)	1.8 (83)	1.4 (75)	.7 (60)	.5 (63)
1964												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	.7	.9	1.1	1.0	1.4	1.4	.6	.5	.3	.7	<.3	<.2
City Hall Annex	1.3	.8	1.0	2.4	2.8	2.3	—	.8	Began 1501			
1501 E. Lycoming										1.0	<.3	<.2
3200 Frankford (horizontal)	.6	.7	.9	1.0	1.5	1.3	.5	.4	.3	.6	.3	.2

Air surveillance, all Philadelphia stations, gross beta pCi/m³):												
Maximum	1.4	1.8	1.8	2.4	3.2	3.3	1.6	1.0	.8	5.6	.7	.6
Minimum	.1	.2	.2	.1	.2	.3	<.1	<.1	<.1	<.1	<.1	<.1
Average[b]	.7 (62)	.8 (60)	1.0 (63)	1.1 (60)	1.5 (63)	1.4 (61)	.6 (60)	.5 (62)	.3 (60)	.7 (75)	<.3 (82)	2.2 (91)
1965												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	<.2	<.2	<.2	<.2	<.4	.5	<.3	<.2	<.1	<.1	<.1	<.1
1501 E. Lycoming	<.2	<.2	<.2	<.2	<.3	.4	.2	<.2	<.1	<.1	<.2	<.1
500 S. Broad	<.2	<.2	<.2	<.2	<.3	.5	.3	<.2	<.1	<.1	<.2	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	<.2	<.2	<.2	<.2	<.3	.5	<.3	<.2	<.1	<.1	<.2	<.1
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Average[b]	<.2 (89)	<.2 (78)	<.2 (89)	<.2 (86)	<.3 (88)	.5 (90)	<.3 (90)	<.1 (93)	<.1 (90)	<.1 (92)	<.2 (85)	<.1 (93)
1966												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	<.1	<.1	<.1	<.2	<.2	<.3	<.2	<.1	<.1	<.1	<.4	<.1
1501 E. Lycoming	<.1	<.2	<.1	<.2	<.2	<.2	<.2	<.1	<.1	<.1	<.3	<.1
500 S. Broad	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.1	<.4	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	1.0	.5	.4	.9	1.1	1.0	.8	.4	.4	.2	2.0	.3
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Average[b]	<.2 (92)	<.1 (82)	<.1 (92)	<.2 (90)	<.2 (93)	<.2 (86)	<.2 (92)	<.1 (90)	<.1 (89)	<.1 (84)	<.4 (84)	<.1 (84)
1967												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	< .8	.3	<.2	<.2	<.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1
1501 E. Lycoming	1.0	.3	<.2	<.2	<.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1
500 S. Broad	<1.6	.3	<.2	<.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.2
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	20.8	.7	.6	.4	.5	.2	.2	.1	.2	1.0	.3	.8
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1
Average[b]	<1.2 (90)	<.3 (81)	<.2 (90)	<.2 (82)	<.1 (82)	<.1 (89)	<.1 (92)	<.1 (92)	<.1 (85)	<.1 (86)	<.1 (82)	<.1 (81)
1968												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	.3	.3	.3	.4	.3	<.2	.3	.2	.2	<.2	<.1	<.2
1501 E. Lycoming	.4	.4	.4	.4	<.3	<.3	.3	.2	.2	<.2	<.1	<.2
500 S. Broad	.4	.3	.3	.3	.3	<.2	.3	.2	.2	<.1	<.1	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	1.1	.7	.7	.7	.5	.6	.5	.4	.5	.3	.3	.5
Minimum	<.1	<.1	<.1	.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1
Average[b]	.4 (76)	.3 (81)	.3 (91)	.4 (70)	.3 (83)	<.3 (89)	.3 (89)	.2 (90)	.2 (75)	<.2 (77)	<.1 (77)	<.2 (83)

Table 2. Gross beta radioactivity in surface air,[a] Philadelphia, August 1961 to December 1971—continued

Sampling by station & year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1969												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	<.2	.2	.2	.2	.4	.5	.4	.5	.4	<.2	<.1	<.1
1501 E. Lycoming	<.2	<.2	.2	.3	.4	.5	.4	.5	.4	.2	<.2	<.1
500 S. Broad	<.2	.1	<.2	.3	.4	.5	.4	.5	.3	<.2	<.1	<.2
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	.3	.3	.7	.5	1.0	1.3	.8	1.0	.6	.3	.3	.9
Minimum	<.1	<.1	<.1	<.1	<.1	<.1	.1	.1	.2	<.1	<.1	<.1
Average[b]	<.2 (78)	.1 (78)	.2 (79)	.3 (80)	.4 (91)	.5 (77)	.4 (88)	.5 (89)	.4 (86)	<.2 (88)	<.1 (84)	<.1 (79)
1970												
Average gross beta radioactivity per station (pCi/m³):												
3200 Frankford	<.1	.2	.2	.4	.5	.7	.5	.5	.2	.2	(c)	(c)
1501 E. Lycoming	<.1	.2	.3	.4	.6	.6	.5	.5	.3	.2	<.3	<.2
500 S. Broad	<.1	.2	<.2	.4	.5	.6	.5	.4	.2	<.2	<.2	<.2
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	.3	.5	.5	1.0	1.2	1.1	1.0	.8	.7	.4	.8	.8
Minimum	<.1	<.1	<.1	.1	.2	.3	.1	.2	<.1	<.1	<.1	<.1
Average[b]	<.1 (87)	<.2 (77)	<.2 (90)	.4 (90)	.5 (87)	.6 (82)	.5 (83)	.5 (85)	.3 (82)	.2 (85)	<.2 (59)	<.2 (60)
1971												
Average gross beta radioactivity per station (pCi/m³):												
1501 E. Lycoming	<.1	<.2	.3	.6	.7	.7	.6	.6	<.2	<.2	<.2	<.2
500 S. Broad	<.1	<.1	<.2	<.4	<.6	.5	.5	.3	<.2	<.2	<.1	<.1
Air surveillance, all Philadelphia stations, gross beta (pCi/m³):												
Maximum	.2	.5	.6	1.4	1.4	1.3	1.4	1.1	.4	.5	.3	.4
Minimum	<.1	<.1	<.1	<.1	<.1	.1	<.1	<.1	<.1	<.1	<.1	<.1
Average[b]	<.1 (50)	<.2 (50)	.3 (60)	.5 (47)	.6 (61)	.6 (57)	.6 (52)	.5 (54)	<.2 (51)	<.2 (58)	<.1 (58)	<.2 (58)

[a] Analysis 1 day after removal of filter up to May 31, 1962; 4 days after removal from June 1, 1962 through October 12, 1966; 3 or 5 days after removal from October 31, 1966.
[b] Figure in parenthesis indicates number of samples represented in average.
[c] Discontinued.

Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1958												
New York Ship Delaware River:												
Gross gamma							*11.5 (9)	18.2 (9)	12.8 (9)	23.0 (9)	45.5 (9)	30.9 (9)
1959												
USPHS (7)												
Philadelphia composite:												
Suspended										4	<1	0
Dissolved										4	<1	0
1960												
New York Ship Delaware River:												
Gross gamma	b44.1	18.1	58.0	43.9	35.3	13.9	11.4	18.6	14.8	19.0	21.2	14.7
USPHS (7) Philadelphia composite:												
Suspended	3	3	0	0	0	1	0	0	0	0	0	3
Dissolved	0	4	3	3	<1	0	0	6	0	0	0	3
1961												
New York Ship Delaware River:												
Gross gamma	6.3	16.3	11.0	11.3	13.2	12.0		$\bar{x}$=13.5		12.0	23.8	16.8
Torresdale Filter Plant Delaware River:												
Gross beta								2.1	5.8	9.5	28.4	44.0
Queen Lane Reservoir Schuylkill River:												
Gross beta								7.1	4.7	5.5	11.4	38.1
USPHS (7) Philadelphia composite:												
Suspended	0		0	1	0	9	5	0	1	7		13
Dissolved	0		0	0	0	0	6	4	3	14		22
1962												
New York Ship Delaware River:												
Gross gamma	17.3	20.2	16.4	13.4	$\bar{x}$=19.1			$\bar{x}$=24.0			$\bar{x}$=23.7	
Torresdale Filter Plant Delaware River:												
Gross beta	68.9	48.0	47.5	29.5	13.8	16.2	12.6	13.7	14.6	10.7	19.6	23.2
Gross gamma	146.0	87.6	49.9	55.4	32.8	10.7	22.1	44.6	23.9	26.3	44.7	40.4
Queen Lane Reservoir Schuylkill River:												
Gross beta	30.3	60.3	31.9	27.6	16.2	15.7	7.4	14.0	9.9	7.8	15.9	15.2
Gross gamma	56.7	51.3	45.8	31.0	35.9	43.8	19.0	19.5	56.7	23.2	16.9	30.5
USPHS (7) Philadelphia composite:												
Suspended	31	10	22	23	5	6	4	9	5	5	16	15
Dissolved	37	18	21	24	12	14	22	13	14	15	24	33

*1959 New York Ship, gross beta annual average 26 1.
**Philadelphia, Ben Franklin Bridge (3).
3/8/59–5/1/60, 10 samples, gross beta $\bar{x}$=20, range 3–45 pCi/liter.
***Philadelphia Naval Shipyard (3).
3/8/59–1/10/60, 9 samples, gross beta $\bar{x}$=30, range 2–105 pCi/liter.

See footnotes at end of table.

Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1963												
Delaware River:												
New York Shipbuilding:												
Gross gamma	43.9	84.5	92.2	38.7	42.1	12.5	40.2	37.2	37.8	29.3	24.2	32.7
Torresdale Filter Plant:												
Gross beta	33.0	92.2	63.6	20.1	56.6	16.2	25.1	19.0	18.5	15.0	17.5	21.0
Gross gamma	42.5	116.0	74.1	44.8	157.0	31.3	33.3	29.8	21.8	38.3	82.8	55.2
Schulykill River; Queens Lane Reservoir:												
Gross beta	31.8	51.9	66.7	22.6	32.1	26.9	24.4	23.9	24.7	12.1	4.2	12.7
Gross gamma	87.6	28.5	94.5	16.2	76.4	51.6	31.2	47.3	26.2	74.1	52.9	63.9
Delaware River:												
Station #6 (Navy Yard):												
Gross beta:												
Suspended	[e] <1	<1	5	<1	<1	<1	7	<1	<1	<1	<1	<1
Dissolved	[e] 3	14	14	17	10	9	350	17	9	8	7	7
Gross alpha, dissolved				(z)								
Station #7 (Wharton St):												
Gross beta:												
Suspended (pCi/mg)	[e] <1	<1	10	<1			4	<1	<1	<1	<1	<1
Dissolved	[e] 7	44	15	13			16	7	9	28	10	7
Gross alpha, dissolved										(s)		
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	[e] <1	<1	3	1	<1		<1	<1	<1	6	<1	<1
Dissolved	[e] 3	18	11	11	22		14	9	5	7	8	6
Gross alpha, dissolved				(z)								
USPHS Philadelphia composite sample:												
Suspended	23	—	64	—	19	16	11	5	8	17	4	7
Dissolved	59	—	39	—	30	32	24	20	18	16	13	12
1964												
Delaware River:												
New York Shipbuilding:												
Gross gamma	21.5	24.4	23.8	16.7	13.6	13.8	17.7	13.3	18.3	17.9	15.1	15.7
Torresdale Filter Plant:												
Gross beta	11.2	4.8	5.6	11.2	13.7	—	—	0	13.7	0	6.1	5.5
Gross gamma	83.4	37.3	2.9	27.4	178.0	—	—	59.7	61.8	62.7	6.4	54.5
Schulykill Fiver:												
Queen's Lane Reservoir:												
Gross beta	13.0	18.5	6.2	23.2	13.7	—	—	4.6	2.3	<1.0	5.1	25.3
Gross gamma	83.9	43.0	19.2	49.3	132.0	—	—	25.0	44.8	35.3	52.8	40.9
Delaware River:												
Station #6 (Navy Yard):												
Gross beta:												
Suspended	<1	<1	—	<1	1	<1	—	—	—	—	—	—
Dissolved	8	4	—	8	15	9	11	6	6	8		
Gross alpha, dissolved					2			1	1	3		
Station #7 (Wharton St):												
Gross beta:												
Suspended	<1	<1	—	<1	<1	<1	—	—	—		—	
Dissolved	8	4	—	7	15	10	32	6	7	7	—	
Gross alpha:												
Dissolved							4		1	2		
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	<1	<1	—	<1	<1	<1	—		—	—	—	—
Dissolved	8	5	—	9	16	8	13	6	9	7	—	—
Gross alpha:												
Dissolved							2	1	3	2		
USPHS Philadelphia composite sample:												
Suspended	20	15	13	14	10	0	5	5	1	1	7	2
Dissolved	13	11	9	11	8	12	15	11	7	8	10	5

1965												
Delaware River:												
New York Shipbuilding:												
Gross gamma	14.3	19.7	14.8	8.4	10.4	16.2	9.3	5.9	7.8	9.8	6.5	[d] 7.3
Torresdale Filter Plant:												
Gross beta:												
Suspended	11.9	21.2	[e] .2	6.6	3.2	9.2	.1	.2	2.3	1.6	4.5	2.0
Dissolved	—	—	[e] .7	7.2	9.6	9.1	0	1.3	3.0	1.5	10.7	3.9
Gross gamma	27.0	—										
Schulykill River:												
Queens Lane Reservoir:												
Gross beta:												
Suspended	12.1	24.6	[e] .5	10.0	3.0	8.8	.9	1.4	6.1	2.2	2.9	2.8
Gross gamma:												
Dissolved	47.6	—	[e] .6	7.1	3.0	9.5	1.7	0	.1	.9	7.6	1.2
Delaware River:												
Station #6 (Navy Yard):												
Gross beta:												
Suspended	<1	<1	<1	<1	<1	<1	Discontinued by NERHL			([f])	[f] <1	[f] 1.0
Dissolved	13	8	8	9	9	9						
Gross alpha:												
Dissolved	1	3	2	3	3	86	Discontinued by NERHL			([f])	[f] 5.6	[f] 4.3
Station #7 (Wharton St):												
Gross beta:												
Suspended	<1	<1	<1	<1	<1	<1	Discontinued by NERHL			([f])	.6	1.2
Dissolved	6	8	8	9	6	7					7.3	1.6
Gross alpha:												
Suspended												
Dissolved		4		2	3	60	Discontinued by NERHL			([f])	1.2	
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	<1	<1	<1	—	<1	<1	Discontinued by NERHL			([f])	3.6	2.5
Dissolved	8	19	7	—	5	6					2.1	5.4
USPHS Philadelphia composite sample:*												
Suspended	29	3	4	3	1	1	1	2	2	2	1	2
Dissolved	6	7	6	6	4	7	8	8	10	6	5	4
*(Sampling discontinued in December 1965)												
1966												
Delaware River:												
Torresdale composite:												
Gross beta												
Suspended											<1.7	<1.0
Dissolved											<3.4	<1.9
Torresdale filter plant:												
Gross beta:												
Suspended	3.3	7.3	3.3	1.9	0	1.5	.4	2.3	1.8	.3	[g] <1.0	<1.0
Dissolved	2.3	4.9	3.1	.2	2.5	2.2	3.2	1.7	3.6	.5	9.2	<3.1
Gross alpha:												
Dissolved											<1.0	<1.6
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	2.5	2.5	1.1	5.5	.3	3.0	0	2.7	1.3	1.0	<1.0	<1.0
Dissolved	3.3	2.6	2.0	1.2	1.3	3.3	5.1	7.8	.5	<.1	<8.3	<1.0
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	.5	4.0	3.0	.7	2.2	5.8	.2	.3	3.1	.1	<1.0	<1.0
Dissolved	2.8	2.1	6.8	2.8	2.2	6.4	3.3	.8	1.2	.3	<5.4	<2.3
Station #7 (Wharton St):												
Gross beta:												
Suspended	.3	1.7	4.0	3.5	2.7	2.1	2.9	.4	1.3	.1	<1.0	<1.0
Dissolved	1.7	1.9	4.2	2.3	1.6	4.6	4.8	6.3	5.4	<.4	<5.6	<2.0
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	1.1	3.2	4.9	.8	2.8	4.4	1.1	2.8	1.3	.6	<1.0	<1.0
Dissolved	1.7	1.3	3.0	1.9	4.8	2.8	3.2	5.8	2.9	.4	<4.2	<2.3
Gross alpha:												
Suspended												<.5
Dissolved											<1.0	

See footnotes at end of table.

Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
USPHS Philadelphia composite sample:												
Suspended	5	0	3	4	—	—	1					3
Dissolved	6	5	6	3	—	—	5					5
1967												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.5	<1.1	<1.5	<1.0	<1.3	<1.0	<1.0	<1.0	<1.0
Dissolved	<2.2	<1.0	<1.0	<2.6	<1.1	<1.1	<2.0	<1.6	<1.2	<1.8	<1.0	<1.7
Gross alpha:												
Suspended			[a] <.6		[a] <1.2	[a] <.8						
Torresdale filter plant:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.5	<1.4	<4.7	<1.0	<1.5	<1.0	<1.0	<1.0	<1.3
Dissolved	<3.5	<1.0	<1.9	<1.7	<1.4	<1.1	<1.7	<3.2	<1.4	<3.5	<2.0	<3.1
Gross alpha:												
Suspended				<.5		<.7						
Dissolved	[b] <1.6	<1.0								<.5	<.6	<.7
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.8	<1.4	<1.0	<1.0	<1.5	<1.0	<1.0	<1.0	<1.0
Dissolved	<3.1	<1.0	<1.5	<5.2	<1.0	<1.0	<1.1	<2.4	<2.0	2.8	<1.0	3.8
Gross alpha:												
Suspended					<2.1			<.5				
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.1	<2.8	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<1.6	<1.0	<1.0	<1.2	<1.2	<1.0	<1.8	<1.6	<1.2	<1.6	<1.0	<1.6
Gross alpha:												
Suspended					<3.1	<.6	<.9					
Dissolved					<.6							
Station #7 (Wharton St):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<4.5	<1.2	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<1.8	<1.0	<1.0	<3.9	<1.3	<1.0	<2.0	<1.2	<1.9	<1.8	<1.0	<1.1
Gross alpha:												
Suspended	<.5				<.7							
Station #9 (Lehigh Ave):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<2.3	<4.8	<1.0	<1.5	<2.3	<1.0	<1.0	<1.0	<1.0
Dissolved	<2.7	<1.0	<1.2	<1.3	<1.2	<1.2	<5.3	<5.1	<1.9	<1.6	<1.0	<1.4
Gross alpha:												
Suspended			<.5		<5.2							
Dissolved					<.6						<.6	
USPHS Philadelphia composite sample:												
Suspended	1	1	1	0	0	0	0	0		0	0	0
Dissolved	5	3	0	0	0	0	0	1		0	0	0
1968												
DelawareRver:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<5.6	<1.7	<1.0	<1.0	<1.1	<1.5	<1.0	<1.7	<2.3	<2.6	<2.4	<1.8
Torresdale filter plant:												
Gross beta:												
Suspended	<5.5	<1.0	<1.8	<1.0	<1.0	<1.4	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0
Dissolved	<6.6	<1.3	<1.0	<1.0	<1.2	<1.6	<1.0	<1.5	<3.2	<3.5	<5.2	<4.6

Gross alpha:												
Suspended			<.5									
Dissolved	<.5	<2.0	<.6						<.6	<.5	<1.1	<1.3
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<2.9	<1.0	<1.0	<1.0	<3.1	<1.7	<1.0	<1.0	<1.0	<2.7	<1.0	<1.0
Dissolved	4.2	<1.9	<1.0	<1.0	<1.7	<2.4	<1.7	<2.1	<3.0	<3.7	3.5	4.2
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta												
Suspended	<1.4	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.4	<1.0
Dissolved	<3.1	<1.6	<1.0	<1.0	<1.0	<1.8	<1.0	<1.5	<2.0	<2.4	<2.6	<2.1
Gross alpha:												
Suspended	<.6										<.5	
Station #7 (Wharton Street):												
Gross beta:												
Suspended	<1.3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	<3.4	<1.0	<1.0	<1.0	<1.2	<1.0	<1.0	<1.3	<2.7	<2.7	2.3	2.3
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.2
Disso ved	<2.7	<2.0	<1.0	<1.0	<1.2	<1.4	<1.4	<1.6	<3.0	<2.8	<2.6	2.3
Gross alpha:												
Suspended										<.5		
1969												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<1.0	<1.3	<1.1	<1.1	<1.1	<1.1	<2.4	<1.1	<1.0	<1.0	<1.2
Dissolved	<1.8	<2.3	<3.0	<2.1	1.6	2.6	2.6	2.8	2.8	2.2	1.8	2.3
Gross alpha:												
Suspended								<.5				
Torresdale filter plant:												
Gross beta:												
Suspended	<1.0	<1.0	<1.1	<1.0	<1.8	<1.0	<1.0	<1.6	<1.7	<1.3	<1.5	<1.3
Dissolved	2.4	<2.0	3.2	<2.1	<8.4	2.6	3.2	3.7	5.3	3.0	3.4	3.4
Gross alpha:												
Suspended								<.6	<.6			<.5
Dissolved	<1.3				<.5			<1.0	<1.9	<.9	<.9	<.5
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<3.1	<1.0	<1.0	<1.1	<1.2
Dissolved	<2.9	<1.3	3.6	<1.9	3.1	<2.1	4.0	<3.0	2.7	2.9	2.2	2.1
Gross alpha:												
Dissolved								<.5				
1969												
Delaware River:												
Station #6, (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0	<1.0	<1.1
Dissolved	<2.7	5.3	4.6	2.7	2.3	3.8	<3.0	3.3	4.0	2.9	2.8	2.4
Gross alpha:												
Suspended										<.5		
Station #7 (Wharton Street):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.7	<1.0	<1.0	<1.0	<1.2
Dissolved	2.2	2.9	3.5	2.8	2.1	2.9	2.7	3.2	3.0	<2.3	2.4	2.2
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.5	<1.0	<1.0	<1.0	1.0
Dissolved	<2.6	2.7	3.3	2.5	5.3	8.3	7.9	6.3	7.6	4.2	2.4	2.6
Gross alpha:												
Suspended								<.6				
Dissolved					<1.6	<2.2	<1.8	<1.7	<1.5	<.7		<.8

See footnotes at end of table.

Table 3. Average radioactivity in raw surface water (pCi/liter) Philadelphia, 1958–1962—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1970												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.4	<1.6	<1.0	<1.0	<2.8	<1.0	<1.4	<1.6	<1.0	<1.1	<1.0	<1.0
Dissolved	2.9	2.7	2.9	2.4	2.0	2.5	2.0	2.3	2.0	3.5	2.2	2.1
Gross alpha:												
Suspended		<.5			<.5					<.5		
Torresdale filter plant:												
Gross beta:												
Suspended	<1.3	<1.0	<1.8	<3.8	<1.4	<1.0	<1.0	<1.0	<1.3	<1.6	<1.0	<1.7
Dissolved	3.2	2.5	2.7	2.7	2.7	3.8	3.0	5.7	2.8	4.3	3.8	3.1
Gross alpha:												
Suspended				<.5				<.5				
Dissolved					<.5		<.7	<.6	<.7	<1.0	<2.4	<.9
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.2	<1.0	<1.1	<1.5	<1.0	<1.0	<1.0	<1.0	<2.4	<8.0	<1.0
Dissolved	2.9	3.0	3.3	3.7	2.6	3.5	2.9	3.4	<2.5	4.9	4.8	3.3
Gross alpha:												
Suspended				<.6							<.7	
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<2.2	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	3.8	3.8	3.6	2.8	3.3	2.6	3.2	3.0	2.5	3.7	1.9	2.1
Gross alpha:								<.5				
Suspended								<.6				
Dissolved												
Station #7 (Wharton Street)												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.4	<1.0	<2.3	<1.0	<1.9	<1.4	<1.0	<1.0
Dissolved	2.5	2.3	2.8	2.2	<2.1	2.6	2.3	3.6	3.9	4.1	2.7	2.2
Gross alpha:												
Dissolved								<.7	<1.6	<.5		
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<1.0	<1.0	<1.0	<1.6	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Dissolved	2.6	<2.0	3.2	2.4	<2.1	2.9	2.6	3.2	2.6	4.3	3.9	2.0
Gross alpha:												<1.5
Suspended				<.5						<.6		
Dissolved												
1971												
Delaware River:												
Torresdale composite:												
Gross beta:												
Suspended	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.3	<1.0	<1.0	<1.7	<1.2
Dissolved	2.2	2.3	<1.3	1.5	2.3	2.0	<2.5	<2.5	2.7	3.1	<1.4	<1.5
Gross alpha:												
Suspended		<.5							<.5			
Torresdale filter plant:												
Gross beta:												
Suspended	<1.3	<1.6	<3.2	<1.5	<3.6	<2.6	<1.8	<2.2	<1.1	<1.0	<2.1	<3.0
Dissolved	<4.3	3.0	2.3	<1.6	1.9	2.4	<2.1	3.0	4.1	4.7	<2.4	2.8
Gross alpha:												
Suspended					<.6				<.5		<.7	
Dissolved	<.8							<.7				<.7
Schulykill River:												
Queen's Lane Reservoir:												
Gross beta:												
Suspended	<1.0	<1.0	<1.4	<1.0	<1.0	<1.0	<1.0	<1.4	<1.0	<1.0	<1.3	<1.0
Dissolved	2.9	2.1	2.1	2.7	<3.2	3.2	3.5	<1.6	<2.5	3.6	<2.4	2.2
Gross alpha:												
Suspended											<.5	<.6
Delaware River:												
Station #6 (NE sewage treatment plant):												
Gross beta:												
Suspended	<1.0	<1.8	<1.0	<1.0	<1.0	<1.0	<1.0	<1.8	<1.0	<1.0	<1.8	<1.2

Dissolved	2.3	2.7	<1.4	<1.3	1.2	2.4	<2.0	2.0	3.3	<3.1	<1.3	<1.4
Gross alpha:												
Suspended								<.5	<.5			
Station #7 (Wharton Street):												
Gross beta:												
Suspended	<1.0	<1.4	<1.0	<2.2	<1.0	<1.0	<1.0	<1.8	<1.0	<1.0	<1.9	<1.0
Dissolved	<2.1	<1.5	<1.3	<1.4	<1.3	2.6	<2.2	<1.5	<2.8	<2.5	<1.6	1.7
Gross alpha:												
Dissolved								<.9				
Station #9 (Lehigh Avenue):												
Gross beta:												
Suspended	<1.0	<2.2	<1.1	<1.0	<1.0	<1.2	<1.0	<1.4	<1.0	<1.0	<1.6	<1.1
Dissolved	<2.0	<2.3	<1.5	1.6	1.5	<1.7	<1.6	2.9	3.1	3.4	<1.6	<1.5
Gross alpha:												
Suspended							<.5					
Dissolved						<.8						

[a] New York Shipbuilding Corporation averaged the results from daily samplings, July 1958 through December 1958.
[b] New York Shipbuilding Corporation averaged the results from weekly composite samples from January 1959.
[c] Stations 6, 7, and 8 established January 1, 1963. Analysis by Northeast Radiological Health Laboratories. If not reported, gross alpha was less than 1 pCi/liter dissolved or less than 1 pCi/mg of suspended material within a sample.
[d] Discontinued.
[e] Torresdale and Queen's Lane Stations discontinued gross beta and gamma and initiated beta radioactivity suspended and dissolved analysis.
[f] Stations 6, 7 & 9 reinstituted by Philadelphia in November 1965. Station #6 sampling site changed to N.E. Sewage Treatment plant in November 1965.
[g] Initiated wide beta counter October 17, 1966. Analysis for gross beta and gross alpha as suspended and dissolved radioactivity. All alphas were <0.4 pCi/liter unless indicated.
[h] Gross alpha in pCi/liter. If not reported, alpha was less than 0.4 pCi/liter after January 1967.

Table 4. Average radioactivity in precipitation, process water and milk (pCi/liter) Philadelphia, 1961—1971

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1961												
Precipitation:												
Number of samples								2	1	2	4	3
Total depth (inches)								3.42	2.41	1.83	2.04	2.78
Gross beta								14	138	516	2,824	1,472
Gross gamma											2,610	707
Tap water:												
Gross beta								5.4	6.0	5.2	23.8	19.8
Milk pasteurized:[a]												
Average gross beta										[a] 568	691	592
Iodine-131										[b] 14.6	123	100
1962												
Precipitation:												
Number of samples	1	5	4	4	3	3	2	4	3	4	2	2
Total depth (inches)	2.95	3.51	3.91	3.69	1.85	7.40	2.30	6.58	2.77	.95	4.60	2.11
Gross beta	1,295	1,790	1,398	784	1,345	1,260	1,225	477	940	2,053	1,424	994
Gross gamma	877	1,423	732	543	851	793	1,320	784	1,114	2,540	1,862	1,233
Tap water:												
Gross beta	20.3	19.5	24.5	15.3	10.1	10.1	9.6	7.4	14.3	7.8	10.1	10.1
Milk pasteurized:[a]												
Average gross beta	953	660	875	438	967	734	763					
Iodine-131	88	70	71	72	114	<10.0	<12.1	<20.4	172	92.0	88.4	<46.8
1963												
Precipitation:												
Number of samples	2	1	3	1	3							
Total depth (inches)	2.31	2.19	3.94	1.13	1.06	2.88	3.13	3.35	6.44	.09	6.67	1.76
Gross beta	2,215	1,629	1,393	2,814	1,618							
Gross gamma	1,852	1,630	1,340	4,604	1,573							
Tap water:												
Gross beta	15.1	24.5	27.7	19.8	24.7	15.8	14.4					
Milk pasteurized:[a]												
Average gross beta	762	580	600	395	783	431						
Iodine-131	<10.0											
1964												
Precipitation:												
Total depth (inches)	3.92	2.83	1.94	5.27	.47	.21	3.83	.49	2.42	1.73	1.64	5.13
1965												
Precipitation:												
Total depth (inches)	2.35	2.18	3.19	2.33	1.23	2.85	3.22	4.05	3.02	2.02	1.05	1.85
Milk pasteurized:												
Average concentrations:												
Strontium-89 and strontium-90	11.0	9.0			14.3	13.7	13.5	5.0	7.3			
Strontium-90										20.4	17.8	15.1
Iodine-131	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Yttrium-90										11.0	11.4	17.5
1966												
Precipitation:												
Total depth (inches)	2.82	4.30	.68	4.35	2.95	.41	2.35	1.63	8.70	5.12	2.36	4.33
Gross alpha:												
Suspended											<.4	<.4
Dissolved											<1.1	<.9
Tap water:												
Gross beta:												
Lycoming											[d] <3.2	[d] <5.8
Broad											<2.2	<2.2
Milk pasteurized:												
Average concentrations:												
Strontium-89 and strontium-90						14.4	15.7	18.0	12.2			
Strontium-89											<13.7	12.8
Strontium-90	16.4	14.8	12.3	10.2	10.8					17.2	17.4	<22.8
Iodine-131	<10.0	<10.0	<10.0	<10.0	<10.0	16.6	14.0	<10.0	<10.0	<10.0	<10.0	—
Yttrium-90	15.2	15.0	13.6	9.0	10.5	10.9	12.5	11.6	16.8			

See footnotes at end of table.

Table 4. Average radioactivity in precipitation, process water and milk (pCi/liter) Philadelphia, 1961—1971—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1967												
Precipitation:												
Number of samples	2	4	6	4	5	4	8	7	3	1	2	6
Total depth (inches)	1.67	1.82	4.53	2.17	3.49	4.12	7.11	7.08	2.96	2.00	1.99	5.88
Gross beta:												
Suspended	194.4	<12.1	<6.0	<5.1	<8.7	<1.5	<1.5	<1.0	<1.0	<1.0	<3.6	<104.1
Dissolved	20.5	40.8	24.6	46.3	23.9	9.0	<6.1	<3.8	<3.9	4.2	24.2	77.3
Gross alpha:												
Suspended	<.4	<.5	<.4	<.4	<4.5	<.6	<.4	<.4	<.4	<.4	1.4	<.4
Dissolved	<.7	<.8	<.4	<.4	<5.9	<.5	<.4	<.9	<.4	<.4	1.0	<.5
Tap water:												
Gross beta:												
Lycoming	<2.1	<1.0	<1.4	<1.0	<1.4	<1.0	<1.0	<2.9	<1.2	<1.2	<1.0	<1.7
Broad	<3.4	<1.0	<1.0	<2.3	<1.3	<1.0	<1.1	<5.6	<1.6	<1.4	<1.4	<3.1
Milk pasteurized:												
Average concentrations:												
Strontium-89	<5.0	<5.2	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.1	<5.5	<5.0	<5.0
Strontium-90	25.3	15.0	14.2	14.0	9.4	15.4	14.5	7.3	15.2	17.8	<12.8	<14.6
Iodine-131	<15.3	<10.0	<10.0	<17.5	13.6	<16.4	<10.0	<11.8	<10.0	<10.0	<10.0	<10.0
1968												
Precipitation:												
Number of samples	3	1	6	1	5	4	2	1	2	3	8	4
Total depth (inches)	2.90	1.40	4.98	1.57	5.17	5.89	2.00	1.24	.44	3.15	4.17	2.54
Gross beta:												
Suspended	<26.6	2.5	<2.8	2.0	46.8	5.3	<10.9	5.0	3.4	<1.1	<3.1	<8.3
Dissolved	38.9	34.2	21.4	16.2	54.6	12.0	32.0	36.7	17.8	8.0	13.3	18.4
Gross alpha:												
Suspended	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4
Dissolved	<.4	5.4	<.6	<.4	<.4	<.4	<.4	<.4	<.8	<.4	<.8	<1.9
Tap water:												
Gross beta:												
Lycoming	<2.2	<1.2	<1.1	<1.0	<1.0	<1.0	<1.0	<1.0	<1.9	<2.0	<2.6	<1.6
Broad	<2.7	<2.0	<1.5	<1.0	<1.0	<1.1	<1.0	<1.6	<2.3	<2.7	<3.3	2.8
Milk pasteurized:												
Average concentrations:												
Strontium-89	<5.0	<5.0	<5.0	<6.2	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<6.9
Strontium-90	10.9	13.8	<8.3	<12.1	14.6	<9.6	<6.0	<13.2	9.5	8.6	<7.2	<17.2
Iodine-131	<10.0	<10.0	<10.0	<11.2	<10.8	—	<10.0	<10.0	<10.0	<10.0	<10.0	<10.8
1969												
Precipitation:												
Number of samples	5	3	3	5	4	5	8	4	3	3	2	5
Total depth (inches)	1.57	1.88	1.92	1.68	3.30	7.31	8.33	2.66	4.38	1.13	1.97	7.23
Gross beta:												
Suspended	<2.7	<3.3	2.3	10.2	5.5	<5.1	<7.3	6.0	<3.1	<2.7	3.6	<2.9
Dissolved	12.1	12.1	18.0	30.9	24.5	39.0	46.8	21.1	18.9	8.4	15.5	<4.2
Gross alpha:												
Suspended	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.4	<.6	<.6	<.4
Dissolved	<.9	<.4	<.4	<.4	<.4	<.4	<.4	<.8	<.7	<.9	<.7	<.4
Tap water:												
Gross beta:												
Lycoming	2.7	2.3	2.8	<1.8	1.8	2.0	2.2	2.6	<2.5	<2.3	2.1	2.2
Broad	<5.3	2.6	2.2	<1.6	2.2	2.1	2.8	2.4	<2.2	<2.3	2.9	2.1
Milk pasteurized:												
Average concentrations:												
Strontium-89	<6.0	<5.0	—	<7.1	8.2	<7.2	14.3	<5.0	—	6.4	—	—
Strontium-90	<8.9	<5.0	—	<6.1	<7.2	<6.4	<5.7	<11.6	<7.0	11.1	20.6	—
Iodine-131	<10.5	<10.0	18.8	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.2	<10.0
1970												
Precipitation:												
Number of samples	2	4	6	4	4	4	5	1	2	2	5	4
Total depth (inches)	.74	2.08	3.83	6.12	2.57	4.60	2.75	3.99	.82	3.66	4.71	3.27
Gross beta:												
Suspended	<1.6	<5.7	9.2	6.8	20.7	13.0	<4.8	5.4	9.5	1.3	<2.6	<1.0
Dissolved	6.5	14.7	43.1	27.2	60.2	93.6	31.7	10.8	18.1	9.3	9.6	<6.5
Gross alpha												
Suspended	<.4	<.4	<.5	<.4	<.5	<.4	<.6	<.4	<.4	<.6	<.5	<.4
Dissolved	<.4	<.4	<.4	<.4	<.7	<.5	<.4	1.3	< .4	<.4	<.6	<.6
Tap water:												
Gross beta:												
Lycoming	2.1	2.0	2.0	2.0	<2.4	2.1	2.2	2.8	2.5	2.5	2.0	2.5
Broad	2.6	2.0	2.7	<1.9	2.5	2.7	2.0	3.2	1.9	3.3	2.1	2.2
Milk pasteurized:												
Average concentrations:												
Strontium-90	18.6	13.4	<6.6	7.0	11.2	8.6	<7.8	<5.2	<8.2	10.0	* <2.0	2.8
Iodine-131	<10.0	<10.0	<10.0	<10.2	<10.0	<10.0	<10.0	<10.0	—	<10.0	<10.0	<10.0

See footnotes at end of table.

Table 4. Average radioactivity in precipitation process water and milk (pCi/liter) Philadelphia, 1961—1971—continued

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1971												
Precipitation:												
Number of samples	3	6	3	2	4	1	2	4	5	4	5	3
Total depth (inches)	2.13	5.43	2.58	1.84	4.10	1.01	4.84	9.61	5.83	3.84	5.37	1.21
Gross beta:												
Suspended	<2.9	<2.6	6.6	62.5	52.2	22.5	1.6	7.9	<1.0	<1.5	<3.0	<1.3
Dissolved	26.0	10.1	15.9	58.2	33.8	19.5	10.0	<3.9	2.8	6.5	<5.7	11.2
Gross alpha:												
Suspended	.4	.4	.4	.4	.4	.4	.4	.8	.4	.4	.4	.4
Dissolved	1.1	.4	.4	.4	.4	.4	.4	.5	.4	.6	.4	.7
Tap water:												
Gross beta:												
Lycoming	<2.4	2.9	<2.0	<1.4	<1.6	1.2	1.7	<1.8	2.3	<1.9	<1.7	1.5
Broad	6.4	2.2	1.7	<1.9	2.3	2.2	<2.4	2.1	2.6	<1.8	2.6	2.2
Milk pasteurized:												
Average concentrations:												
Strontium-90	-------	5.1	5.5	<6.8	<20.0	<14.7	6.2	6.6	<6.2	7.9	7.1	<3.8
Iodine-131	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0

[a] Gross beta radioactivity assessment was initiated in October 1961. The technique involved evaporating 20 ml of raw milk to dryness in a crucible and combusting at 600° C. for 3 hours to remove organic constituents. The residue was taken up in nitric acid, transferred to a planchet, the nitric acid evaporated and the planchet counted.

[b] Determined by the Jefferson Medical College radiation laboratory using resin extraction technique and a 3-inch NaI (T1) crystal.

[c] Discontinued.

[d] After November 1966 gross alpha radicactivity was <0.4 pCi/liter in each sample for Lycoming and Broad stations except: Broad—December 1968, <0.6; January 1969, <0.5; and August 1970, <0.5; Lycoming—August 1970, <0.7; October 1970, <0.5; and December 1970, <1.3.

[e] MDA reduced from 5 pCi/liter to 2 pCi/liter.

[f] This sample was not the same as the PHS pasteurized milk network sample (*9*).

If the iodine-131 iodide ion test indicated greater than 10 pCi/liter, the milk was analyzed for strontium-90, strontium-89, barium-140 and lanthanide radioactivity. If the iodine-131 iodide test indicated less than 10 pCi/liter, only the strontium-90 determination of whole milk was completed.

A dual ion exchange column is used for the analysis of strontium-90. Yttrium is removed by an anion exchange resin, eluted with HCl and precipitated with oxalic acid. The minimum detectable activity for strontium-90 was 5 pCi/liter until October 1970. Beginning in December 1970, the minimum detectable activity was reduced to 2 pCi/liter by increasing counting time. The practical reporting level has been continued at 5 pCi/liter. If the iodide test indicates a concentration greater than 10 pCi/liter of iodine-131, a lanthanum extraction procedure is used between successive precipitations of yttrium oxalate. The standard deviation of replicate analysis of strontium-90 by this ion exchange procedure has consistently been ± 1.5 pCi/liter or ± 5 percent whichever is greater.

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Joint Dental Radiation Survey In Puerto Rico, 1968

Michael Gileadi [1,2]

The objective, scope, and methods used in the 1968 Joint Dental Survey Project, sponsored jointly by the Health Department of Puerto Rico Nuclear Center and School of Dentistry, University of Puerto Rico, are described. Health hazards associated with dental x-ray diagnostic procedures in Puerto Rico in 1968 are evaluated, and relevant statistical and technical data pertinent to the use of x rays in the dental profession on the Island are presented.

Puerto Rico—the smallest island of the Great Antilles, with an area of approximately 3,500-square miles and a population of 2,739,100 in 1968—has undergone a tremendous economic and social development during the past 30 years.

Along with a general improvement in health care, the annual rate of dental x rays taken on the island increased significantly. Highlights of statistical data relating to dental radiography in Puerto Rico during 1968, are presented in figure 1 (*1, 2*).

Because of the nature of x radiation, dental radiography, while indispensable as a diagnostic tool in modern dentistry, at the same time, is unavoidably accompanied by certain health hazards. The primary purpose of the Joint Dental Radiation Survey Puerto Rico–1968, was to evaluate the health hazards associated with dental radiography in frequency as well as in magnitude.

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[2] The responsibility for radiation protection and control (associated with the use of radiation in medicine, education, and commerce in Puerto Rico) rests with the Radiological Health Program in the Department of Health, Commonwealth of Puerto Rico.

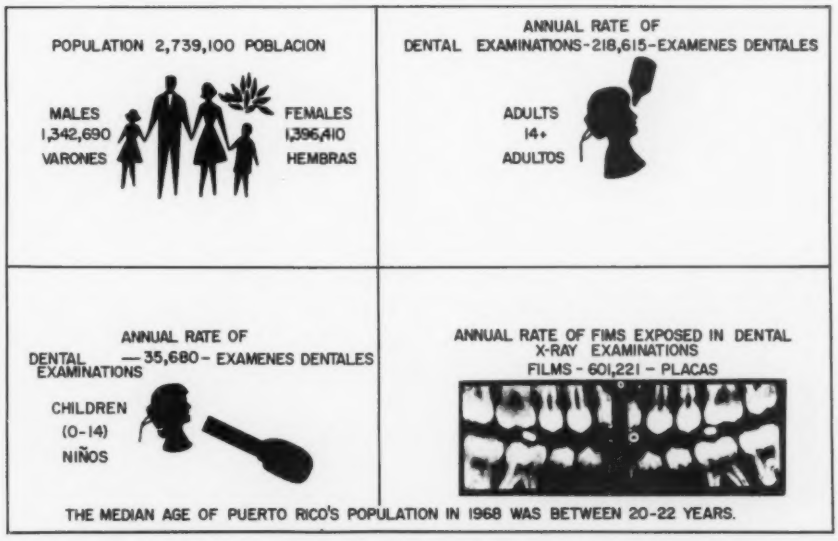

Figure 1. Statistical data highlights relating to dental radiography in Puerto Rico during 1968

The frequency of the health hazard is characterized by the annual rate of dental x-ray examinations, while the magnitude of the effect is described by the gonadal dose associated with each procedure considered.

Indices selected for quantitating the health hazards associated with dental x-ray diagnostic each procedure are:

1. per capita per annum exposure
2. per capita per annum gonadal dose.

Since the magnitude of the unintentional dose delivered during dental radiographies to the patient (and also to dental personnel) is related to the technical parameters of the dental x-ray unit used for radiography, a detailed study was made on all operative dental x-ray units and their technical characteristics (7). Significant results of this study are presented in tables 1 through 3 and figures 2 and 3. Table 1 indicates the number of operative dental x-ray units by type of medical facility in Puerto Rico, 1968.

Table 1. Reported number of operative dental x-ray units by medical facility, Puerto Rico, 1968

Medical facilities with dental x-ray unit	Public institutions	Private offices	Total	Percent
1	36	340	397	90
2	7	26	33	7.4
3 or more	4	7	11	2.6
Grand total	47	373	441	100

Figure 2 shows distribution of operative dental x-ray units in Puerto Rico by year of installation from 1940 to 1968. From figure 2, it is learned that in 1940, with a population of 1,869,255, there were 16 operative dental x-ray units in Puerto Rico. In 1968, with a population of 2,739,100, the number of operative dental x-ray units on the island was 441. This is to say, that between 1940 and 1968, the number of dental x-ray units increased 27.5 times. Presented in a form standardized for population, this corresponds to an increase from .88 units per 100,000 population in 1940 to 24.5 units per 100,000 population in 1968; i.e., close to a 28-fold increase. The population per dentist and per operative x-ray unit in Puerto Rico is presented in table 2.

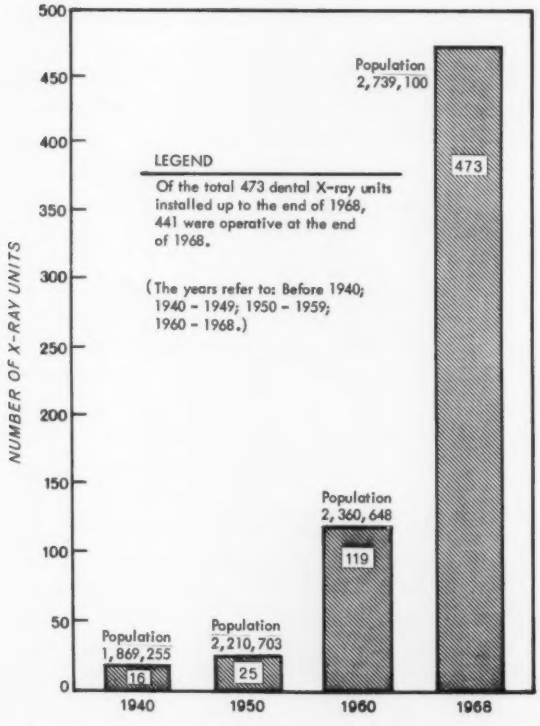

Figure 2. Distribution of operative dental x-ray units by year of installation (from 1940 to 1968)

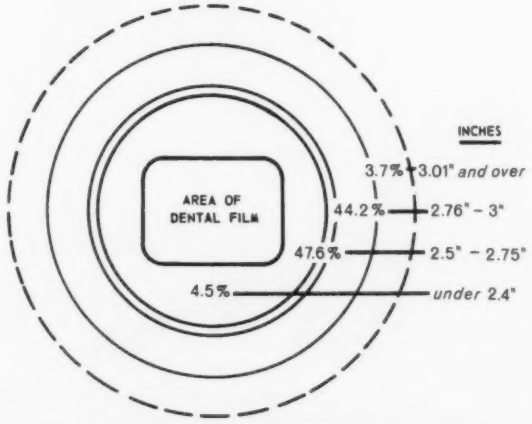

Figure 3. Distribution of dental x-ray units by beam diameter, Puerto Rico, 1968

Table 2. Distribution of dental x-ray units in public institutions and private offices by geographic location, population per dentist and population per dental x-ray unit, Puerto Rico, 1968

Geographic location* and population	Number of public institutions with dental x-ray units	Number of operative dental x-ray units in public institutions	Number of private offices with operative dental x-ray units	Number of operative dental x-ray units in private offices	Total number of operative dental x-ray units	Total number of practicing dentists	Population per practicing dentist	Population per operating dental x-ray unit
Western region, 416,300	17	8	36	36	44	42	9,911	9,461
Southern region, 493,500	12	3	48	52	55	75	6,580	8,972
Northern areas, Caguas, Fajardo, Arecibo, Bayamon, 1,168,500	21	13	92	99	112	68	17,183	10,433
San Juan metropolitan area, 660,800	19	22	190	208	230	302	2,175	2,873
Puerto Rico, 2,739,100	69	46	366	395	441	487	5,624	6,211

* See figure 4.

Table 3. Distribution of dental x-ray units by cone type Puerto Rico, 1968

Cone type	Number of units	Percent
Short point	361	81.85
Long	39	8.84
Short open	14	3.17
Long open	5	1.13
Others		1.13
Cephal	3	
Panoram	2	
Not available	17	3.89
Total	441	100

Unintentional irradiation accompanying dental radiography endangers primarily the eyes, the facial area and the thyroid. Exposing the eye lens to x rays may cause opacity of the lens and may also be conducive to cataracts. Dr. K. Z. Morgan states that 500–900 fatal thyroid tumors result yearly from dental radiography (*3–4*) in the United States.

Cognizant of the hazard associated with dental x-ray examinations, and realizing that there is no such thing as a "safe" minimum quantity of radiation, all available precautions are taken to reduce the skin exposure and gonadal dose to a minimum compatible with the diagnostic objective.

Among the most available precautions to reduce exposure in radiodentistry are:

1. proper collimation (beam size),
2. proper filtration, and
3. the use of high-speed films, which may reduce the skin exposure by as much as a factor of four.

In table 3, the distribution of dental x-ray units by cone type is presented. The type of the cone is related to the resulting beam aperture. Figure 3 presents the distribution of

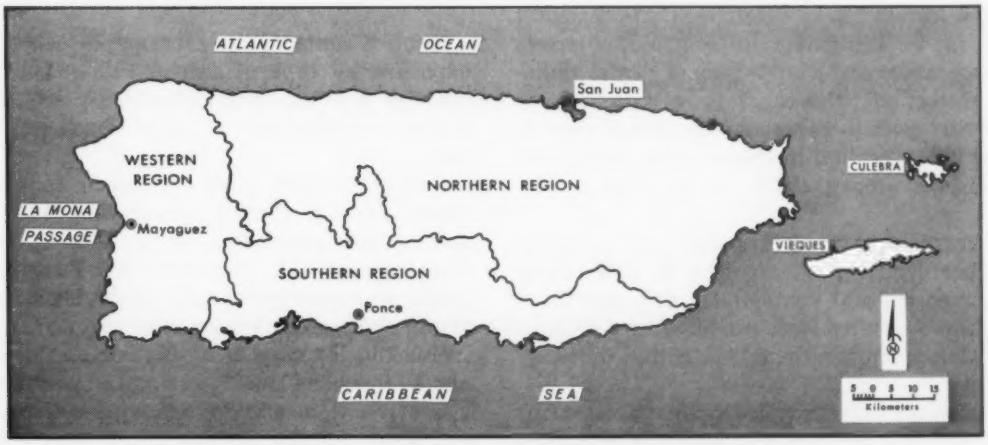

Figure 4. Puerto Rico and its regional subdivisions

Table 4. Annual rate of dental and medical diagnostic total x-ray examinations per 100 population, Puerto Rico, 1968

Geographic location	Population	Annual rate of dental x-ray examinations	Rate of dental x-ray examinations per 100 population	Rate of all x-ray diagnostic examinations per 100 population
Western region	416,300	15,373	3.6	55.3
Southern region	493,500	41,723	8.4	52.5
Northern region (San Juan metropolitan area excluded)	1,168,500	52,553	4.4	43.8
San Juan metropolitan area	660,800	138,154	20.9	98.1
Total	2,739,100	254,295	9.2	60.2

dental x-ray units with respect to beam diameter compared with the actual area of the dental film.

According to the recommendation of the Academy of Oral Roentgenology, as well as the National Council for Radiation Protection (NCRP), the maximum acceptable size of the beam diameter at the film was determined to be 3 inches. According to figure 3, 96.3 percent of all operative dental x-ray units met this limitation in Puerto Rico in 1968. In order to appreciate the progress made, it should be noted that in 1961, only 53.5 percent of all surveyed dental units met the above specification.

In 1968, 82 percent of all dental x-ray units in Puerto Rico had a minimum filtration of 1.5 mm of aluminum equivalent or more.

Most public dental facilities in Puerto Rico use high speed films, as do many private dentists.

Therefore, it can be concluded that the dental radiographic equipment in Puerto Rico meets the standards conducive to proper dental radiation protection practices.

With respect to frequency or annual rate of dental radiographies in Puerto Rico, the survey established, among other things, that:

1. there were 254,295 dental radiographies performed in Puerto Rico in 1968, using over 600,000 dental films (*1*), and
2. these services were rendered by 487 practicing dentists using 441 dental units.

The annual rate of dental x-ray examinations and their rate per 100 population is presented in table 4.

Dosimetric measurements within the framework of the present survey were carried out in the School of Dentistry, University of Puerto Rico, using films, TLD discs, and LiF powder TLD's.

Testicle exposure measurements were carried out in vivo, indicating an average of 3.9 mR exposure for a full mouth dental x-ray examination (14 films) using 65 kV, 10 mA. Table 5 compares the testicle exposures received in full-mouth dental x-ray examinations as determined by various investigations.

Table 5. Testicle exposures due to full-mouth dental x-ray examinations (14 films each) as measured by various investigators

Investigator	Year of publication	(kVp)	(mA)	Average exposure (mR)
Stanford & Vance (*9*)	1955	65	10	4.76
Richards (*6*)	1958	65	10	4.285
Kline et al (*5*)	1970	65	10	5.46
Joint x-ray survey Puerto Rico	1971	65	10	3.86

Table 6 contains the average per capita skin exposure by type of dental radiography and average per capita gonadal dose by type of dental radiography, compiled from published data.

One of the most urgent problems concerning dental care in Puerto Rico is improving the dentist per population ratio. The School of Dentistry of the University of Puerto Rico produces a new generation of highly qualified young dentists for Puerto Rico every year, thus increasing the number of dentists on the Island and at the same time lowering the professional age of dentists and injecting new techniques and ideas into the Island's dental practice.

In order to cope with the ever increasing

Table 6. Average per capita skin and gonadal exposure by type of dental x-ray examination and by sex

Sex	Average per capita skin exposure (mR)			Average per capita gonadal exposure (mR)		
	Single film examination	Full mouth examination	Both types of examination	Single mouth examination	Full mouth examination	Both types of examination
Male	60.29	105.83	166.13	0.02	0.03	0.05
Female	57.21	95.70	152.92	.004	.007	.01
Total	58.72	100.67	159.39	0.01	0.002	0.03

demand for more and better dental care in Puerto Rico, and at the same time, to free the dentists from certain routine tasks, a group of paramedical dental professionals are being educated in the School of Dentistry of the University of Puerto Rico. These include dental assistants, dental hygienists and dental laboratory technicians.

While every dental x-ray procedure is unavoidably associated with certain irradiation hazards, every precaution is being taken in order to reduce these health hazards to a minimum compatible with the medical objective.

The increase of dental tomographies is a case in point, since a dental tomography reduces the exposure rate from the approximately 9,940 mR associated with a 14-film full-mouth examination to about 800–900 mR associated with tomography. It furnishes about the same medical information as a 14 film full-mouth examination. Since 1968, the number of newly installed dental tomographic units has been on the increase, not only in public institutions, but also in private practice, especially in pedodontic facilities.

This is the first comprehensive survey on dental radiography in Puerto Rico. It is hoped that this mutual undertaking by the Department of Health, the Puerto Rico Nuclear Center and the School of Dentistry will provide a useful reference for continued surveillance and protection in the field of dental radiography in Puerto Rico.

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SECTION I. MILK AND FOOD

Milk Surveillance, February 1973

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs, Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radio-

Figure 1. Milk sampling networks in the Western Hemisphere

strontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963–March 1966 (*3*) and are used for general radiation calculations.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during June 1972 with 37 laboratories participating in an experiment on a milk sample containing known concentrations of iodine-131, cesium-137, strontium-89, and strontium-90 (*5*). Of the 17 laboratories producing data for the networks reported in *Radiation Data and Reports*, 13 participated in this study.

The accuracy results of this study for these 13 laboratories are shown in table 1. The accuracy of the cesium-137 measurements continues to be excellent as in previous experiments. However, both the accuracy and precision need to be improved for iodine-131, strontium-89, and strontium-90 which could probably be accomplished through recalibration.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addi-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration	Number of laboratories in each category				Experimental 2σ error (pCi/liter)
	Acceptable [a]	Warning level [b]	Unacceptable [c]	Total	
Iodine-131 (96 or 99 pCi/liter)	7 (58%)	1 (8%)	4 (33%)	12	6
Iodine-131 (438 or 464 pCi/liter)	11 (85%)	0	2 (15%)	13	25 or 28
Cesium-137 (53 or 54 pCi/liter)	11 (92%)	0	1 (8%)	12	6
Cesium-137 (295 or 303 pCi/liter)	11 (85%)	2 (15%)	0	13	17
Strontium-89 (29 or 30 pCi/liter)	9 (82%)	0	2 (18%)	11	6
Strontium-89 (197 or 201 pCi/liter)	3 (33%)	1 (11%)	5 (56%)	9	11 or 12
Strontium-90 (32.1 or 32.4 pCi/liter)	4 (33%)	4 (33%)	4 (33%)	12	1.9
Strontium-90 (150.5 or 151.2 pCi/liter)	6 (55%)	0	5 (45%)	11	8.7

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

tion, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*6*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*6*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range has also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2–standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≧ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≧ 20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≧ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the February 1973 issue of *Radiation Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported in *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown

Table 2. Concentration of radionuclides in milk for February 1973 and 12-month period, March 1972 through February 1973

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	NA	5	0	6
Alaska:	Palmer [c]	P	3	4	0	4
Ariz:	Phoenix [c]	P	NA	0	0	0
Ark:	Little Rock [c]	P	7	9	0	3
Calif:	Sacramento [c]	P	NA	1	0	0
	San Francisco [c]	P	NA	0	0	0
	Del Norte	P	7	11	0	7
	Fresno	P	0	1	0	3
	Humboldt	P	3	3	0	3
	Los Angeles	P	0	1	0	2
	Mendocino	P	2	3	0	4
	Sacramento	P	0	2	0	3
	San Diego	P	0	1	0	4
	Santa Clara	P	10	2	0	3
	Shasta	P	2	2	0	5
	Sonoma	P	2	2	0	4
Colo:	Denver [c]	P	NA	3	0	1
	East	R	NS	NA	NS	4
	Northeast	R	1	NA	NS	1
	Northwest	R	NA		[d] 0	0
	South Central	R	NS	NS	NS	NS
	Southeast	R	NS	NA	NS	0
	Southwest	R	NS	NA	NS	2
	West	R	NA	NA	0	2
Conn:	Hartford [c]	P	NA	5	0	5
	Central	P	5	7	11	13
Del:	Wilmington [c]	P	NA	8	11	8
D.C:	Washington [c]	P	NA	6	11	4
Fla:	Tampa [c]	P	4	4	23	35
	Central	R	5	5	37	42
	North	R	7	6	13	14
	Northeast	R	6	5	59	34
	Southeast	R	6	5	44	48
	Tampa Bay area	P	6	5	28	34
	West	R	6	8	15	13
Ga:	Atlanta [c]	P	NA	9	15	9
Hawaii:	Honolulu [c]	P	3	2	0	1
Idaho:	Idaho Falls [c]	P	5	4	0	0
Ill:	Chicago [c]	P	7	5	12	8
Ind:	Indianapolis [c]	P	NA	5	0	2
	Central	P	4	7	0	9
	Northeast	P	5	6	0	10
	Northwest	P	7	8	15	11
	Southeast	P	5	7	0	8
	Southwest	P	8	7	10	10
Iowa:	Des Moines [c]	P	NA	4	0	0
	Iowa City	R	6	7	0	7
	Des Moines	P	5	6	0 (3)	4
	Little Cedar	R	5	7	0	6
	Le Mars	R	4	4	0	4
Kans:	Wichita [c]	P	NA	6	0	0
	Coffeyville	P	NA		14	9
	Dodge City	P	NA		6	6
	Falls City, Nebr	R	NS		NS	
	Hays	P	NA		8	6
	Kansas City	P	NA		7	8
	Topeka	P	NA		4	0
	Wichita	P	NA		5	5
Ky:	Louisville [c]	P	NA	7	11	4
La:	New Orleans [c]	P	7	12	0	3
Maine:	Portland [c]	P	NA	6	14	21
Md:	Baltimore [c]	P	NA	6	0	5
Mass:	Boston [c]	P	6	6	13	14
Mich:	Detroit [c]	P	NA	7	0	6
	Grand Rapids [c]	P	NA	7	0	4
	Bay City	P	6	3	0	5
	Charlevoix	P	9	4	0 (4)	7
	Detroit	P	4	3	0	5
	Grand Rapids	P	10	4	0	7
	Lansing	P	8	4	0 (2)	7
	Marquette	P	10	5	0 (2)	15
	Monroe	P	8	2	0 (2)	3
	South Haven	P	10	5	3 (4)	7
Minn:	Minneapolis [c]	P	NA	7	0	12
	Bemidji	P	9	7	12	17
	Duluth	P	13	15	22	25
	Fergus Falls	P	6	7	7	12
	Little Falls	P	13	18	12	38
	Mankato	P	4	5	5	10
	Marshall	P	4	5	0	10

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for February 1973 and 12-month period, March 1972 through February 1973—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—continued						
Minn:	Minneapolis	P	7	9	11	13
	Rochester	P	8	7	10	9
Miss:	Jackson [c]	P	NA	9	0	7
Mo:	Kansas City [c]	P	NA	5	0	1
	St. Louis [c]	P	NA	6	0	2
Mont:	Helena [c]	P	NA	4	0	0
Nebr:	Omaha [c]	P	NA	5	0	1
Nev:	Las Vegas [c]	P	NA	1	0	0
N.H:	Manchester [c]	P	NA	8	13	14
N.J:	Trenton [c]	P	NA	7	11	6
N. Mex:	Albuquerque [c]	P	NA	1	0	0
N.Y:	Buffalo [c]	P	5	5	0	4
	New York City [c]	P	NA	8	11	6
	Syracuse [c]	P	NA	6	0	5
	Albany	P	4	5	0 (4)	0
	Buffalo	P	5	6	0	0
	Massena	P	NS	7	NS	0
	New York City	P	6	6	0	0
	Syracuse	P	NS	4	NS	0
N.C:	Charlotte [c]	P	NS	8	NS	6
N. Dak:	Minot [c]	P	NA	9	0	5
Ohio:	Cincinnati [c]	P	NA	5	0	4
	Cleveland [c]	P	NA	6	0	5
Okla:	Oklahoma City [c]	P	NA	5	0	2
Oreg:	Portland [c]	P	3	4	0	3
	Baker	P	NA		NA	
	Coos Bay	P	NA		NA	
	Eugene	P	NA		NA	
	Medford	P	NA		NA	
	Portland composite	P	NA		NA	
	Portland local	P	NA		NA	
	Redmond	P	NA		NA	
	Tillamook	P	NA		NA	
Pa:	Philadelphia [c]	P	NA	6	12	4
	Pittsburgh [c]	P	NA	8	0	8
	Dauphin	P	0	4	0	7
	Erie	P	3	5	0	5
	Philadelphia	P	4	5	0	6
	Pittsburgh	P	5	7	0	9
R.I:	Providence [c]	P	NA	6	12	11
S.C:	Charleston [c]	P	6	8	0	10
S. Dak:	Rapid City [c]	P	NA	5	0	1
Tenn:	Chattanooga [c]	P	NA	8	0	7
	Memphis	P	NA	7	0	1
	Chattagnooga	R	NA	10	0	9
	Clinton	R	NA	9	5 (2)	12
	Fayetteville	P	NA	10	9 (2)	8
	Kingston	[d]	NA	10	0	5
	Knoxville	P	NA	8	0 (2)	6
	Lawrenceburg	R	NS	8	NS	10
	Nashville	P	NS	8	NS	7
	Pulaski	R	NA	6	7 (2)	6
	Sequoyah	R	NA		NA	
Tex:	Austin [c]	P	NA	2	0	0
	Dallas [c]	P	NA	5	0	0
	Amarillo	R	NA		NA	
	Corpus Christi	R	NA		NA	
	El Paso	R	NA		NA	
	Fort Worth	R	NA		NA	
	Harlingen	R	NA		NA	
	Houston	R	NA		NA	
	Lubbock	R	NA		NA	
	Midland	R	NA		NA	
	San Antonio	R	NA		NA	
	Texarkana	R	NA		NA	
	Uvalde	R	NA		NA	
	Wichita Falls	R	NA		NA	
Utah:	Salt Lake City [c]	P	5	3	0	3
Vt:	Burlington [c]	P	NA	5	0	9
Va:	Norfolk [c]	P	NA	6	0	6
Wash:	Seattle [c]	P	NA	3	0	1
	Spokane [c]	P	NA	4	0	5
	Benton County	R	NS	1	NS	0
	Franklin County	R	3	1	0	0
	Longview	R	0	4	0	2
	Sandpoint, Idaho	R	7	8	0	8
	Skagit County	R	5	7	0	4
W. Va:	Charleston [c]	P	NA	7	0	5
Wisc:	Milwaukee [c]	P	NA	5	0	5
Wyo:	Laramie [c]	P	NA	2	0	0

See footnotes at end of table.

Table 2. Concentration of radionuclides in milk for February 1973 and 12-month period, March 1972 through February 1973—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		19	18
Edmonton	P	NA		15	14
British Columbia: Vancouver	P	NA		NS	
Manitoba: Winnipeg	P	NA		12	15
New Brunswick: Moncton	P	NA		7	8
Newfoundland: St. John's	P	NA		10	22
Nova Scotia: Halifax	P	NA		15	14
Ontario: Ottawa	P	NA		6	9
Sault Ste. Marie	P	NA		19	21
Thunder Bay	P	NA		11	18
Toronto	P	NA		13	9
Windsor	P	NA		15	7
Quebec: Montreal	P	NA		5	9
Quebec	P	NA		10	19
Saskatchewan: Regina	P	NA		5	11
Saskatoon	P	NA		5	12
CENTRAL AND SOUTH AMERICA:					
Canal Zone: Cristobal [c]	P	NA	1	29	13
Chile: Santiago	P	0	1	0	1
Colombia: Bogota	P	NS	0	NS	0
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Mandeville	P	NS	2	NS	49
Puerto Rico: San Juan [c]	P	NA	1	0	2
Venezuela: Caracas	P	0	1	0	0
PMN network average [e]		5	5	3	5

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting level for this network differs from the general ones given in the text. Sampling results for these networks were equal to or less than the following practical reporting levels:
Cesium-137: Colorado—25 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample collected.

in figure 2. The first column in table 2 under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for February 1973

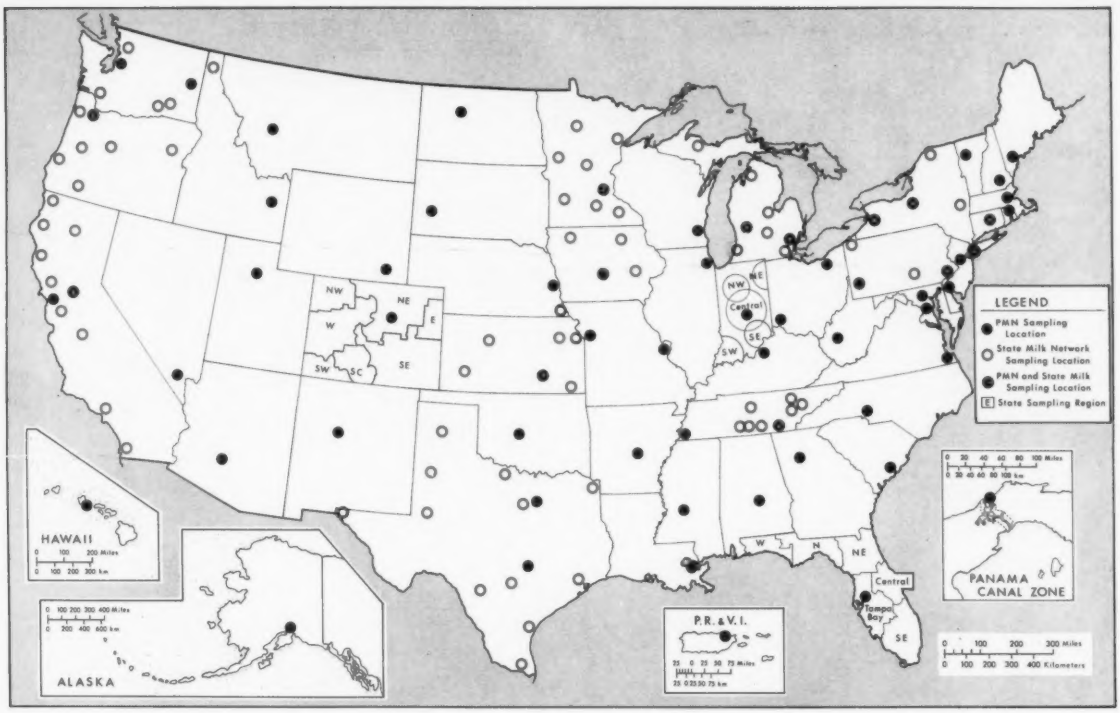

Figure 2. State and PMN milk sampling stations in the United States

and the 12-month period, March 1972 to February 1973. Except where noted, the monthly average represents a single sample for the sampling station. Strontium-89, iodine-131, and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for February 1973 were below the respective practical reporting levels. No strontium-89, iodine-131, or barium-140 was detected.

Strontium-90 monthly averages ranged from 0 to 10 pCi/liter in the United States for February 1973 and the highest 12-month average was 12 pCi/liter (New Orleans, La.) representing 6.0 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 59 pCi/liter in the United States for February 1973, and the highest 12-month average was 48 pCi/liter (Southeast Florida) representing 1.3 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*7*) and Jamaica.

Acknowledgment

Appreciation is expressed to the personnel of the following agencies who provide data from their milk surveillance networks:

Bureau of Radiological Health
Environmental Health & Consumer Protection Program
California Department of Public Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Milk Surveillance Programs, December 1972

National Environmental Research Center—
Las Vegas Environmental Protection Agency

The Milk Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC–LV), consists of 32 regular and five alternate sampling locations (figure 1) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

In the event of a release of radioactivity from the NTS, special sampling within the affected

[1] This network is operated under a Memorandum of Understanding (No. AT (26–1)–539 with the Nevada Operations Office, AEC, Las Vegas, Nev.

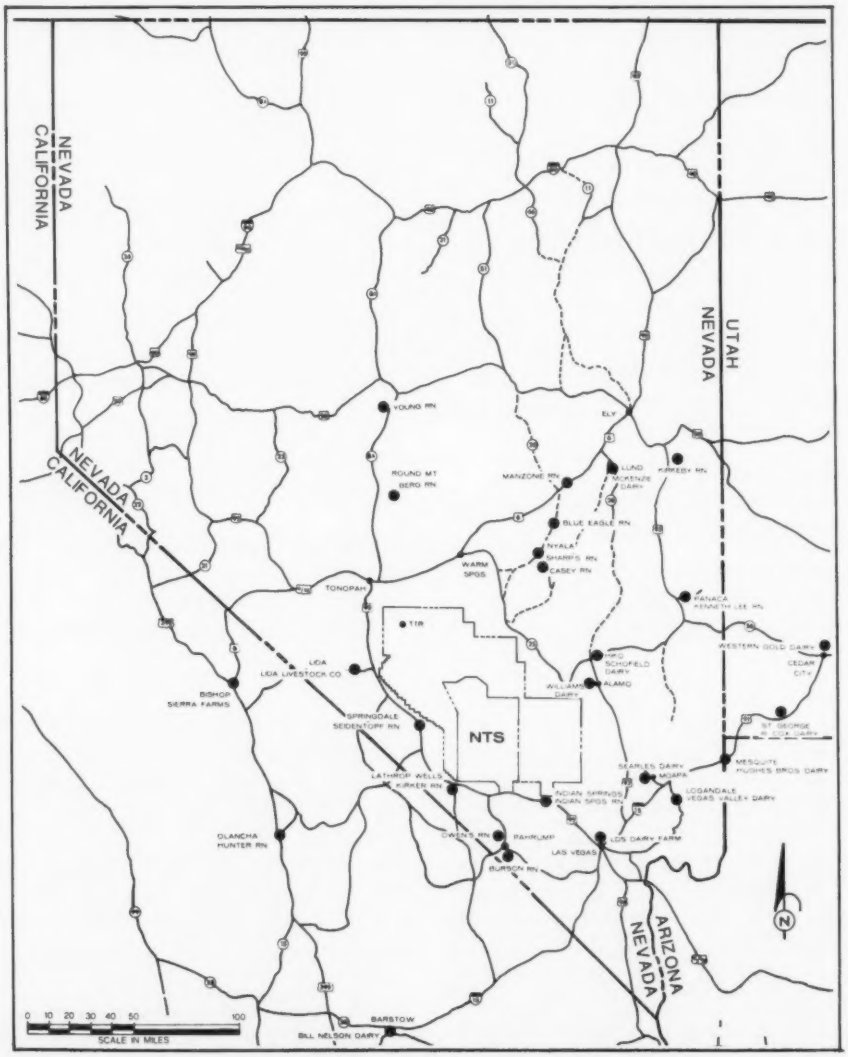

Figure 1. NERC-LV Milk Surveillance Network

area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional milk sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and analytical procedures was included with the milk results reported in the December 1972 issue of *Radiation Data and Reports.*

Results

The analytical results of all milk samples collected in December 1972 by NERC–LV surveillance programs are listed in table 1. With the exception of cesium–137 at levels near the minimum detectable activity (MDA) of 10 pCi/liter, no gamma-emitting fission products were detected in any of the samples by gamma spectroscopy analysis. Levels of tritium and strontium–90 near the MDA's for these radionuclides (~200 pCi/liter and 1 pCi/liter, respectively) were also measured by radiochemistry analyses. Copies of these results were distributed to EPA Regional Offices and appropriate State agencies prior to publication.

Table 1. Milk surveillance results, December 1972

Location	Map number	Date collected (1972)	Sample type [a]	Radionuclide concentrations [b] (pCi/liter)			
				^{137}Cs	^{89}Sr	^{90}Sr	^{3}H
California:							
Bishop:							
Sierra Farms	5	12/ 7	11	<10	<3.0	<1.6	NA
Hinkley:							
Bill Nelson Dairy	13	12/ 5	12	<10	<2.0	<.9	NA
Independence:							
Smith Ranch	14	12/ 7	13	<10	<3.0	3.7±1.4	NA
Olancha:							
Hunter Ranch	30	12/ 8	13	<10	<2.0	<1.1	NA
Nevada:							
Alamo:							
Williams Dairy	1	12/ 1	12	<10	<2.0	2.4±1.3	NA
Austin:							
Young's Ranch	3	12/ 1	13	<10	<2.0	3.0±1.4	NA
Belmont:							
Pine Creek Ranch	4	12/ 1	13	40	<3.0	5.1±1.7	NA
Eureka:							
Martin Ranch	10	12/12	13	<10	<3.0	3.5±1.7	NA
Hiko:							
Schofield Dairy	12	12/ 1	12	<10	<2.0	2.8±1.2	<220
Las Vegas:							
Anderson Dairy	17	12/15	11	<10	<2.0	<1.2	NA
Arden Dairy	18	12/15	11	<10	<2.0	<1.1	NA
LDS Dairy Farms	19	12/15	12	<10	<2.0	<1.3	<240
Lida:							
Lida Livestock Company	21	12/ 1	13	<10	<2.0	<1.2	NA
Logandale:							
Vegas Valley Dairy	22	12 /1	12	<10	<2.0	1.2±1.2	NA
Mesquite:							
Hughes Bros. Dairy	25	12/ 1	12	<10	<2.0	<.9	<220
Moapa:							
Searles Dairy	26	12/ 1	12	<10	<2.0	<1.0	NA
Nyala:							
Sharp's Ranch	28	12/ 6	13	<10	<3.0	<1.6	<220
Pahrump:							
Owen's Ranch	31	12/ 1	13	<10	<2.0	1.6±1.2	NA
Panaca:							
Kenneth Lee Ranch	33	12/ 1	13	<10	<2.0	1.9±1.2	NA
Shoshone:							
Kirkeby Ranch	35	12/13	13	<10	<2.0	1.7±1.3	NA
Springdale:							
Seidentopf Ranch	36	12/ 1	13	<10	<2.0	<1.3	NA
Utah:							
Newcastle:							
Newcastle Dairy	27	12/ 1	12	<10	<2.0	1.8±1.2	NA
St. George:							
R. Cox Dairy	37	12/ 1	12	<10	<2.0	1.9±1.2	NA

[a] 11—Pasteurized milk.
12—Raw milk from Grade A producer(s).
13—Raw milk from family cow(s).
[b] Two-sigma counting error provided when available.
NA, not analyzed.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intake of radionuclides. Programs reported in *Radiation Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	January-June 1971	December 1972
Carbon–14 in Total Diet and Milk	July-December 1971	May 1972
Radiostrontium in Milk	January-December 1971	November 1972
Strontium–90 in Tri-City Diets	January-December 1971	December 1972

Radionuclides in Institutional Diet Samples, January-March 1972

Environmental Protection Agency and Food and Drug Administration

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. Recognizing that the diet is a potentially significant contribution to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. The program is now administered by the Office of Radiation Programs, Environmental Protection Agency with the assistance of the Office of Food Sanitation, Food and Drug Administration, Department of Health, Education, and Welfare (*1*).

This program estimates the dietary intake of radionuclides in a selected population group, ranging from children to young adults of school age. At present 26 institutions (distributed geographically as shown in figure 1) are being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, but teenage boys consumed 20 percent more food per day (*1, 2*). Extrapolating this information, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intake of children.

The sampling procedure is generally the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus between-meal snacks) obtained by duplicating the food intake of a different individual daily. Drinking water —which is not included—is also sampled periodically. Each daily sample is kept frozen until the end of the collection period. It is then packed in dry ice and shipped by air to either the National Environmental Research Center, Las Vegas, Nev. or the Eastern Environmental Radiation Facility, Montgomery, Ala. A detailed description of sampling and analytical procedures has already been presented in Radiological Health Data and Reports (*3*).

Results

Table 1 shows the analytical results for in-

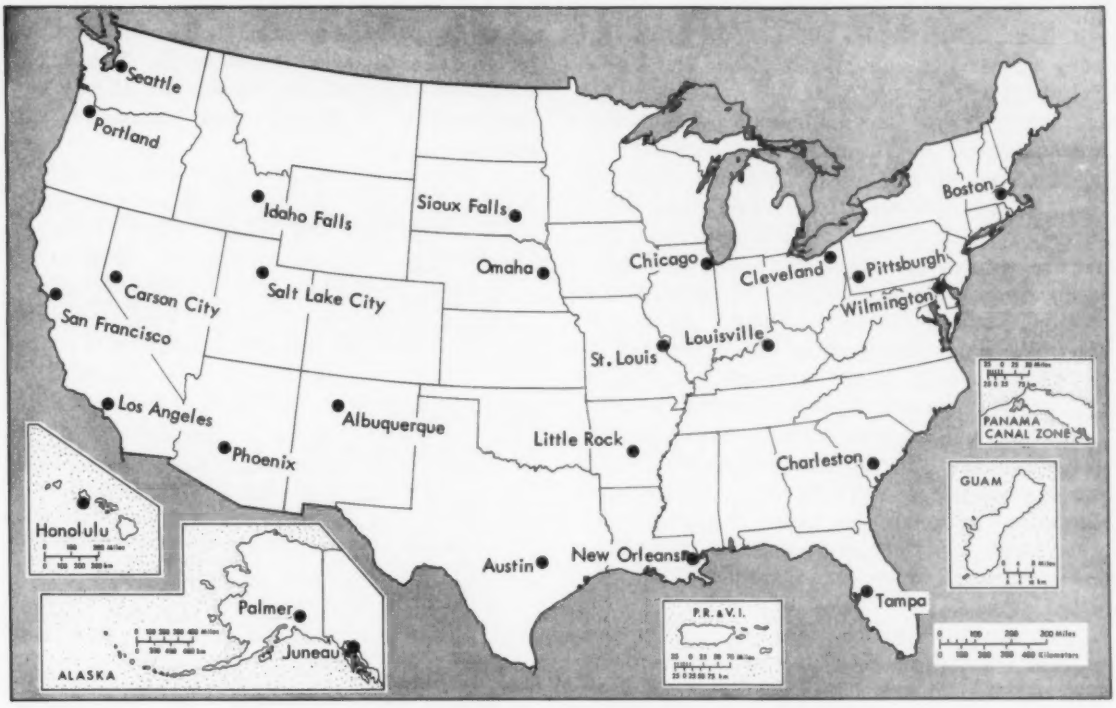

Figure 1. Institutional diet sampling locations as of March 1972

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children January-March 1972

Location of Institution	Month[a]	Total weight (kg/day)	Calcium		Potassium		Strontium-90		Cesium-137	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	Jan	1.57	0.6	0.9	1.9	2.9	4	6	56	88
Palmer	Jan	1.94	.5	1.0	1.7	3.3	14	27	56	108
Ariz: Phoenix	Feb	1.76	.7	1.2	1.7	3.0	4	6	0	0
Ark: Little Rock	Jan	1.73	.7	1.2	1.9	3.2	10	17	14	24
Calif: Los Angeles	Jan[b]	1.41	.3	.4	1.3	1.9	2	3	0	0
San Francisco	Jan[b]	1.62	1.0	1.7	2.1	3.5	3	5	0	0
Del: Wilmington	Feb	1.38	.7	.9	1.0	1.4	5	7	12	17
Fla: Tampa	Jan	.93	.4	.4	1.4	1.3	5	5	21	20
Hawaii: Honolulu	Jan	2.24	.5	1.1	1.4	3.2	5	10	0	0
Idaho: Idaho Falls	Jan[b]	1.52	.9	1.3	1.7	2.6	14	22	20	30
Ill: Chicago	Jan	.34	.4	.1	1.7	.6	4	1	24	8
Ky: Louisville	Jan[b]	1.73	.7	1.2	1.6	2.8	7	12	0	0
La: New Orleans	Jan[b]	1.10	.4	.4	1.9	2.1	6	6	16	18
Mass: Boston	Mar	2.47	.6	1.5	1.4	3.5	4	9	17	42
Mo: St. Louis	Jan[b]	1.14	1.0	1.1	1.9	2.2	5	5	0	0
Nebr: Omaha	Jan	2.59	1.0	2.5	1.4	3.7	6	16	0	0
Nev: Carson City	Jan	1.36	.8	1.0	1.5	2.1	4	6	0	0
N. Mex: Albuquerque		NS								
Ohio: Cleveland	Jan[b]	1.36	.6	.8	1.6	2.2	10	14	22	30
Oreg: Portland	Jan[b]	1.76	.5	.9	1.8	3.2	3	5	13	23
Pa: Pittsburg	Jan[b]	2.89	.3	1.0	1.8	3.6	5	14	0	0
S.C: Charleston	Jan[b]	1.08	.6	.7	1.3	1.4	7	8	0	0
S. Dak: Sioux Falls	Jan[b]	1.19	.8	.9	1.6	2.0	6	7	0	0
Tex: Austin	Jan[b]	1.75	.8	1.4	1.6	2.9	6	10	0	0
Utah: Salt Lake City	Jan[b]	1.96	.5	1.0	1.4	2.7	2	5	0	0
Wash: Seattle	Feb[b]	2.00	.5	1.0	1.6	3.3	5	11	0	0
Institutional average		1.63	0.6	1.0	1.6	2.6	6	10	11	16

[a]Quarterly sample usually collected the first month of the quarter.
[b]Food samples were collected from two or more children who were not between the ages of 9 and 12.
Note: Iodine-131, barium-140, and strontium-89 were not detected at any station during this period.
NS, no sample.

stitutional diet samples collected from all stations during January-March 1972. The stable elements, calcium and potassium, are reported in g/kg of diet. Where applicable, radionuclide concentrations of these samples reported in pCi/kg of diet are corrected for radioactive decay to the midpoint of the sample collection period. Dietary intakes in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.63 kg/day compared to the network average of 1.85 kg/day observed from 1961 through 1971.

Strontium–90 dietary intake averaged 6 pCi/day during this period. Cesium–137 intake averaged 11 pCi/day. These results fall within Range I as defined by the former Federal Radiation Council (*4*). Strontium–89, barium–140, and iodine–131 concentrations were below detectable levels.

All concentrations less than or equal to the appropriate minimum detectable level have been reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2–standard–deviation analytical error. Accordingly, the minimum detectable limits are strontium–89, 5 pCi/kg; strontium–90, 2 pCi/kg; iodine–131, 10 pCi/kg; barium–140, 10 pCi/kg; and cesium–137, 10 pCi/kg.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-March 1971	September 1971
April-June 1971	November 1971
July-September 1971	April 1972
October-December 1971	June 1972

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SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium–226 and strontium–90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1970	June 1972
Colorado River Basin	1968	March 1972
Community Water Supply Study	1969	September 1972
Florida	1969	January 1972
Interstate Carrier Drinking Water	1971	May 1972
Kansas	January-December 1971	February 1973
Michigan	January-June 1970	November 1971
Minnesota	July 1970-June 1971	November 1972
New York	July-December 1970 and January-June 1971	May 1972
North Carolina	1968–1970	September 1972
Radiostrontium in Tap Water, *HASL*	July-December 1971	November 1972
Tritium Surveillance System	October-December 1972	May 1973
Washington	July 1969-June 1970	March 1972
Water Surveillance Programs, *NERC–LV*	November 1972	May 1973

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Water Surveillance Programs, December 1972

National Environmental Research Center—
Las Vegas, Environmental Protection Agency

The Water Surveillance Network,[1] operated by the National Environmental Research Center-Las Vegas (NERC–LV), consists of 90 sampling locations (figures 1 and 2) situated in the offsite area surrounding the Nevada Test Site (NTS). This routine network is operated in support of the nuclear testing programs sponsored by the U.S. Atomic Energy Commission (AEC) and by the Space Nuclear Systems Office, National Aeronautical and Space Administration.

[1] This network is operated under a Memorandum of Understanding (No. AT (26–1)–539) with the Nevada Operations Office, U.S. AEC, Las Vegas, Nev.

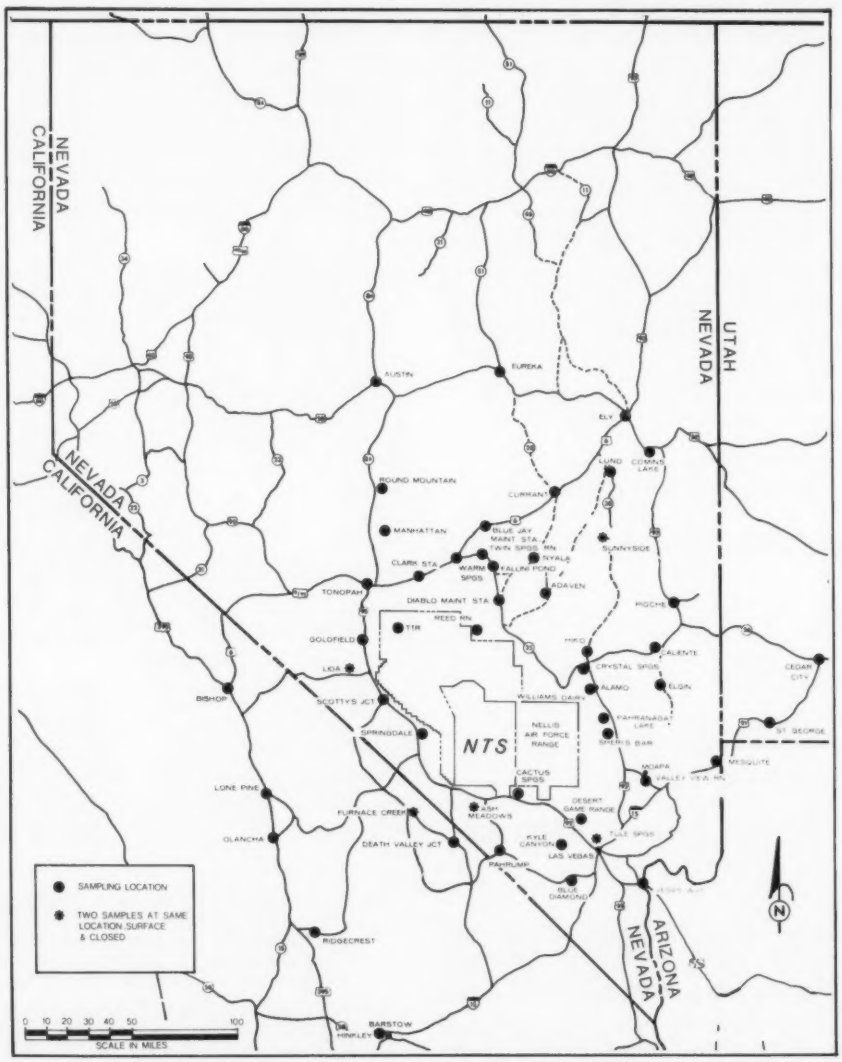

Figure 1. NERC-LV Water Surveillance Network

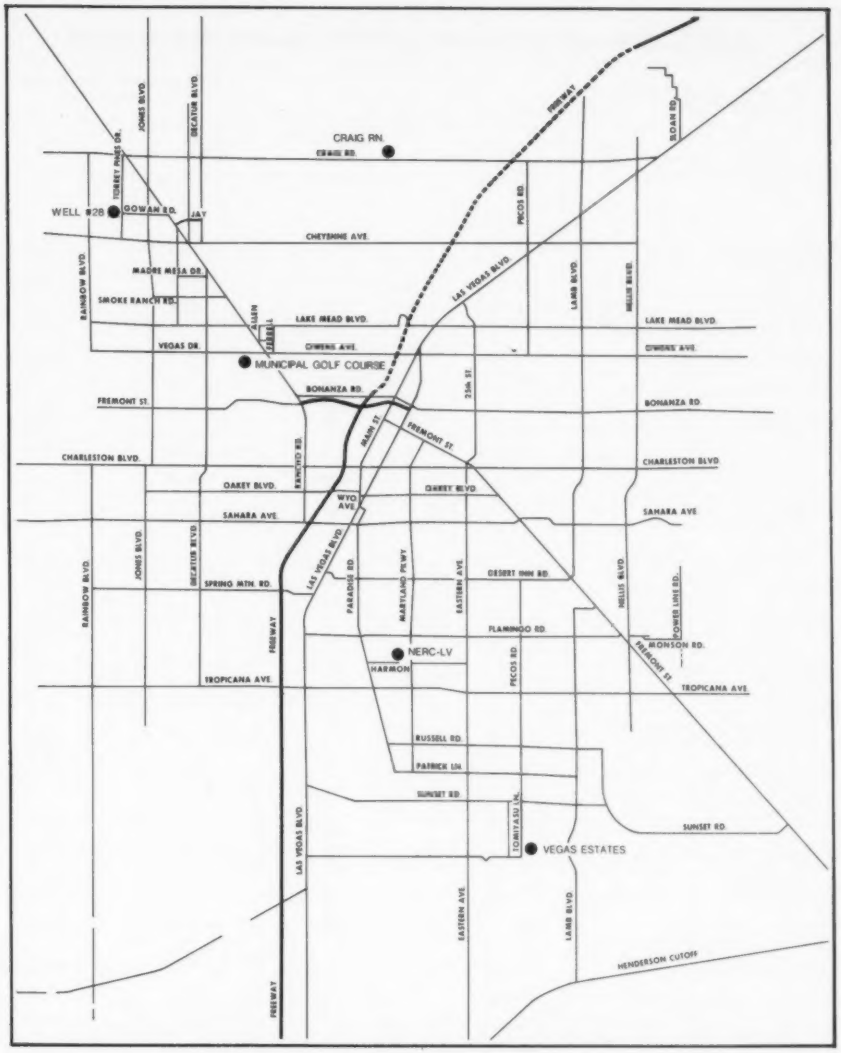

Figure 2. NERC-LV Water Surveillance Network—Las Vegas Valley

In the event of a release of radioactivity from the NTS, special sampling within the affected area is conducted to determine radionuclide concentrations and to take protective action, if required. Additional water sampling networks are operated in support of AEC operations in areas other than the NTS when requested. A complete description of sampling and routine analytical procedures was included with the water results reported in the December 1972 issue of *Radiation Data and Reports*.

For the purpose of identifying the source of the gross radioactivity in all network samples and comparing sample concentrations with both the AEC concentration guides and the PHS Drinking Water Standards, selected samples, from each sampling location are given special analyses at least once a year beginning with calendar year 1972. For surface water samples, the special analyses includes strontium–89, strontium–90, plutonium–238, plutonium–239, uranium, and radium–226.

Table 1. NERC–LV water surveillance results, December 1972—continued

Location	Map number	Data collected	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
California:						
Bishop:						
Fish and Game Office	9	12/ 7	23	<1.1	<3.2	NA
Owens River, 3 miles east	10	12/ 7	22	4.5± 3.8	5.4±3.6	NA
Death Valley Junction:						
Lila's Cafe	21	12/ 8	23	<5.3	7.9±3.7	<240
Furnace Creek:						
Pond	28	12/ 8	21	<3.2	11 ±3.8	NA
Visitors Center	29	12/ 8	27	<3.3	8.1±3.6	NA
Hinkley:						
Bill Nelson Dairy	39	12/ 5	23	11 ± 6.0	6.7±3.5	NA
Little Lake:						
Little Lake Ranch	60	12/ 6	21	16 ± 9.0	26 ±5.0	NA
Lone Pine:						
Diaz Lake	61	12/ 6	21	21 ± 9.6	28 ±4.8	NA
Forest Service Ranger Station	62	12/ 6	23	2.3± 2.0	<3.2	NA
Olancha:						
Haiwee Reservoir	73	12/ 6	21	6.2± 3.6	6.1±3.4	NA
Ridgecrest:						
City Hall	76	12/ 6	23	<3.6	<3.5	NA
Shoshone:						
Chevron Service Station	79	12/ 8	27	<5.0	18 ±4.5	NA
Nevada:						
Adaven:						
Canfield Ranch	1	12/ 5	22	5.6± 3.4	<3.2	NA
Alamo:						
Sheri's Bar	2	12/ 1	23	<2.8	<3.6	NA
Pahranagat Lake	3	12/ 1	21	17 ±.7.9	14 ±4.0	NA
Williams Dairy	4	12/ 1	23	<4.8	9.0±3.7	NA
Ash Meadows:						
Ash Meadows Lodge	5	12/ 1	23	9.0± 6.7	16 ±4.5	<210
Ash Meadows Pond	6	12/ 1	21	19 ± 8.0	21 ±4.6	NA
Austin:						
County Courthouse	7	12/ 1	27	30 ± 7.6	18 ±4.3	NA
Beatty:						
Richfield Service Station	8	12/ 1	23	10 ± 6.6	10 ±4.1	<210
Blue Diamond:						
Post Office	11	12/ 1	23	<3.8	4.8±3.7	<210
Blue Jay Highway:						
Maintenance Station	12	12/ 6	23	3.4± 3.3	<3.2	NA
Cactus Springs:						
Mobil Service Station	13	12/ 1	27	<2.3	<3.5	<210
Caliente:						
Agricultural Extension Station	14	12/ 1	23	3.9± 3.6	4.7. ±3.4	NA
Meadow Valley wash	15	12/ 1	22	5.5± 5.5	14 ±4.0	NA
Clark Station:						
Five Mile Ranch	17	12/ 6	27	<2.1	4.6±3.3	NA
Coyote Summit:						
Sand Spring Well	18	12/ 5	23	34 ± 110	17 ±4.1	NA
Currant Ranch Cafe	20	12/12	27	11 ± 5.0	<3.1	NA
Diablo Highway:						
Maintenance Station	22	12/ 6	23	3.4± 3.2	6.1±3.4	NA
Diablo:						
Reed Ranch	23	12/ 5	21	14 ± 6.0	15 ±4.0	NA
Elgin:						
Water tower	24	12/ 1	23	7.4± 5.5	4.8±3.4	NA
Ely:						
Chevron Service Station	25	12/12	24	2.8± 2.3	3.1±3.1	NA
Eureka:						
Chevron Service Station	27	12/12	24	3.0± 2.9	3.7±3.2	NA
Glendale:						
Chevron Service Station	32	12/ 1	27	<5.2	8.5±3.7	NA
Muddy River	33	12/ 1	22	<5.4	9.7±3.8	NA
Goldfield:						
Alkali Springs	34	12/ 1	21	<4.3	20 ±4.6	NA
Chevron Service Station	35	12/ 1	23	<4.1	9.7±3.7	NA
Hawthorne:						
Walker Lake	36	12/ 1	21	<12	<16	NA
Hiko:						
Crystal Springs	37	12/ 1	27	5.9± 4.2	8.1±3.6	NA
Schofield Dairy	38	12/ 1	23	29 ± 9.1	31 ±4.8	NA
Indian Springs:						
Chevron Service Station	40	12/ 1	23	<2.5	<3.5	<210
Las Vegas:						
Cal-Nev Jet Fuels	41	12/13	23	3.1± 2.7	<3.1	<250
Craig Ranch Golf Course	42	12/13	23	2.6± 2.5	6.4±3.3	380±250
Cunningham Ranch	43	12/13	23	<2.2	<3.1	320±250
Desert Game Range	44	12/ 1	23	8.9± 4.2	<3.5	<210
Desert Game Range Pond	45	12/ 1	21	<2.7	<3.5	<210
Francis Residence	46	12/13	23	<4.2	<3.2	<250
Lab II, NERC-LV	47	12/14	24	<4.5	5.5±3.4	800±260
Lake Mead Vegas Wash	48	12/14	21	<4.5	11.0±3.7	820±260

See footnotes at end of table.

Table 1. NERC–LV water surveillance results, December 1972—continued

Location	Map number	Date collected	Radioactivity concentration [a] (pCi/liter)			
			Sample type [b]	Gross alpha	Gross beta	Tritium
Nevada—continued						
Las Vegas:						
LDS Dairy Farm	49	12/15	23	11.0± 7.7	7.7±3.7	<250
Lloyd Ranch	50	12/13	23	6.4± 5.1	8.3±3.6	<250
LV Water District Well 28	51	12/13	23	<2.0	<3.1	<250
Municipal Golf Course	52	12/13	23	3.5± 2.8	<3.1	<250
Tule Springs	53	12/ 1	23	2.9± 2.7	<3.5	<210
Tule Springs Pond	54	12/ 1	21	5.2± 3.3	<3.5	NA
Vegas Estates	55	12/13	23	<4.5	12.0±3.9	<250
Lathrop Wells:						
Texaco Service Station	56	12/ 1	23	<2.7	<3.6	<210
Lida Junction:						
Cottontail Ranch	57	12/ 1	23	<3.6	14.0±4.0	NA
Lida:						
Lida Livestock Company	58	12/ 1	27	<3.2	<3.3	NA
Pond at storage tank	59	12/ 1	21	4.5± 3.9	<3.3	NA
Lund:						
Gardner Grocery	63	12/11	23	3.4± 2.7	<3.1	NA
Manhattan:						
Country store	64	12/ 1	23	10.0± 6.0	11 ±4.0	NA
Seyler Reservoir	65	12/ 1	21	<3.5	15 ±4.0	NA
Mercury:						
Groom Lake	66	12/ 5	23	6.6± 4.0	7.1±3.5	NA
Moapa:						
Pederson Valley View Ranch	67	12/ 1	27	7.4± 5.9	9.8±3.8	NA
Mt. Charleston:						
Kyle Canyon Fire Station	68	12/ 1	27	<2.4	<3.6	<210
Nyala:						
Sharp's Ranch	72	12/ 6	23	2.8± 2.7	<3.2	NA
Pahrump:						
Texaco Service Station	74	12/ 1	23	<2.2	<3.5	NA
Ploche:						
County Courthouse	75	12/ 1	24	<2.4	6.1±3.7	NA
Round Mountain:						
Mobil Service Station	77	12/ 1	27	<2.2	<3.5	NA
Springdale:						
Peacock Ranch	80	12/ 1	27	<3.2	8.5±3.9	<210
Pond	81	12/ 1	21	<4.7	10 ±4.1	NA
Sunnyside:						
Adam McGill Reservoir	83	12/11	21	5.8± 3.8	4.3±3.2	NA
Wildlife Mgt. Headquarters	84	12/11	27	<1.8	<3.1	NA
Tonopah:						
Jerry's Chevron Station	85	12/ 1	23	<3.1	6.5±3.7	NA
Tonopah Test Range CP-1	86	12/ 1	23	<4.1	5.4±3.4	NA
Warm Springs:						
Fallini's Pond	87	12/ 6	21	15 ± 8.3	40 ±5.4	NA
Hot Creek Ranch	88	12/ 6	27	<3.9	11 ±3.8	NA
Service Station and Cafe	89	12/ 5	27	22 ± 8.9	28 ±4.7	NA
Twin Springs Ranch	90	12/ 6	23	9.0± 4.7	9.1±3.6	NA
Utah:						
Cedar City:						
M. D. Baldwin residence	16	12/ 1	24	<2.6	<3.3	NA
Garrison:						
Rowley Grocery	31	12/13	23	<2.3	<3.1	NA
Newcastle:						
Municipal Reservoir	70	12/ 1	21	<2.2	3.8±3.3	NA
Newcastle Dairy	71	12/ 1	24	5.0± 4.3	5.4±3.7	NA
St. George:						
R. Cox Dairy	82	12/ 1	24	2.6± 2.0	<3.5	NA

[a] Two-sigma counting error provided when available.
[b] 21—Pond, lake, reservoir, stock tank, stock pond.
22—Stream, river, creek.
23—Well.
24—Multiple supply mixed (a water sample consisting of mixed or multiple sources of water, such as well and spring).
27—Spring.
NA, not analyzed.

Results

The routine analytical results of all water samples collected in December 1972 by the NERC–LV Water Surveillance Network are listed in table 1. No gamma-emitting fission products were detected by gamma spectrometry in any of the samples collected. The analytical results of samples selected for special analyses will be reported at a later date.

Copies of these results are distributed to EPA Regional Offices and appropriate State agencies prior to publication.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Plutonium in airborne particulates	July-September 1972	March 1973
Surface air sampling program, 80th Meridian Network, *HASL*	January-December 1970	May 1973

1. Radiation Alert Network February 1973

Quality Assurance and Environmental Monitoring Laboratory
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 68 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Quality Assurance and Environmental Monitoring Laboratory, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during February 1973.

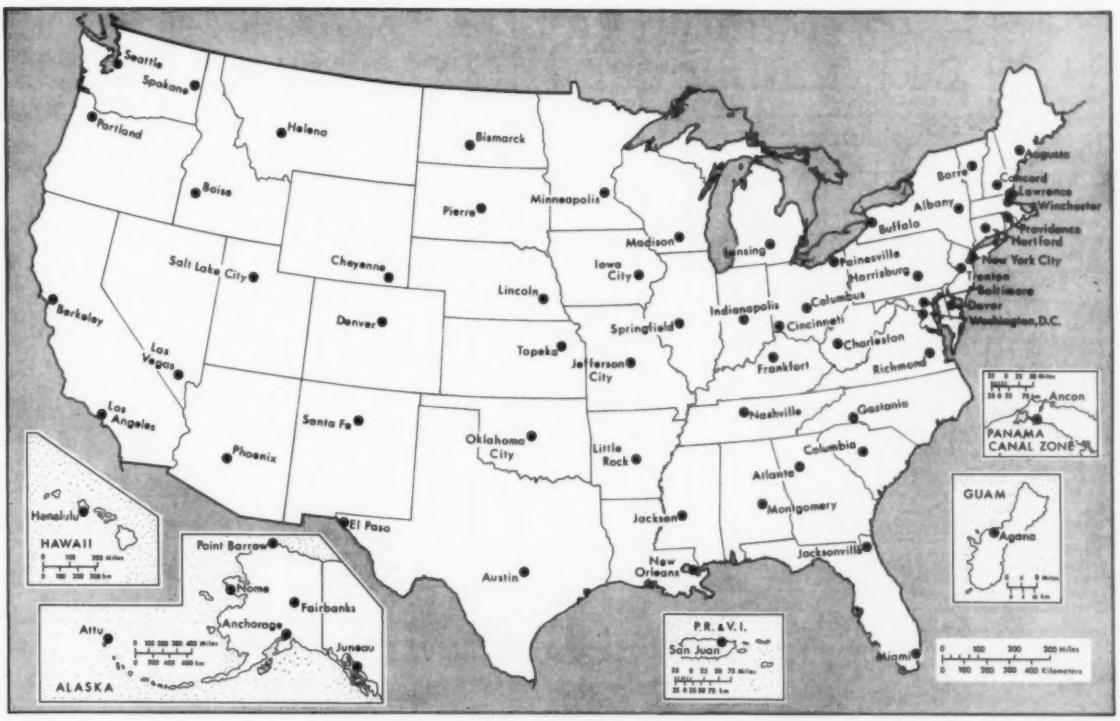

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, February 1973

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Precipitation			
			Maximum	Minimum	Average [a]		Total depth (mm)	Field estimation of deposition		
								Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	1	0	1	2	101	2	101	11
Alaska:	Anchorage	3	0	0	0	0				
	Attu Island	27	0	0	0	0				
	Fairbanks	0				0				
	Juneau	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	12	8	0	3	0				
Ark:	Little Rock	0				0				
Calif:	Berkeley	18	0	0	0	8	99	8	99	0
	Los Angeles	18	1	0	0	0				
C.Z:	Ancon	13	0	0	0	0				
Colo:	Denver	18	4	0	1	0		(b)		
Conn:	Hartford	18	0	0	0	5	46	5	46	0
Del:	Dover	18	0	0	0	0				
D.C:	Washington	15	2	0	0	0				
Fla:	Jacksonville	19	1	0	0	3	117	3	117	3
	Miami	2	0	0	0	1	13	1	13	0
Ga:	Atlanta	20	1	0	0	1	93	1	93	10
Guam:	Agana	0				0				
Hawaii:	Honolulu	18	1	0	0	5	25	(b)		
Idaho:	Boise	18	2	0	0	2	16	2	16	1
Ill:	Springfield	4	1	0	0	0				
Ind:	Indianapolis	7	0	0	0	0				
Iowa:	Iowa City	19	1	0	0	2	23	2	23	0
Kans:	Topeka	20	2	0	1	5	37	5	37	1
Ky:	Frankfort	13	1	0	0	0				
La:	New Orleans	19	1	0	0	6	131	(b)		
Maine:	Augusta	17	0	0	0	5	30	5	30	0
Md:	Baltimore	17	1	0	0	6	53	6	53	0
Mass:	Lawrence	19	0	0	0	2	51	2	51	0
	Winchester	19	0	0	0	3	58	3	58	0
Mich:	Lansing	18	0	0	0	0				
Minn:	Minneapolis	19	0	0	0	3	9	3	9	1
Miss:	Jackson	9	0	0	0	4	109	4	109	0
Mo:	Jefferson City	18	1	0	0	0				
Mont:	Helena	14	2	0	1	0				
Nebr:	Lincoln	18	1	0	0	2	36	2	36	10
Nev:	Las Vegas	19	3	0	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	17	1	0	0	6	90	6	90	1
N. Mex:	Santa Fe	15	1	0	0	2	13	2	13	0
N.Y:	Albany	19	2	0	1	0				
	Buffalo	17	0	0	0	0				
	New York City	0				0				
N.C:	Gastonia	17	7	0	2	5	79			
N. Dak:	Bismarck	18	2	0	1	0		(b)		
Ohio:	Cincinnati	0				0				
	Columbus	2	0	0	0	0				
	Painesville	20	0	0	0	9	54	9	54	13
Okla:	Oklahoma City	0				0				
Oreg:	Portland	18	1	0	0	4	58	4	58	1
Pa:	Harrisburg	13	1	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	17	0	0	0	0				
S.C:	Columbia	8	1	0	0	2	167	2	167	0
S. Dak:	Pierre	14	3	1	1	0				
Tenn:	Nashville	19	1	0	0	8	87	8	87	0
Tex:	Austin	19	7	1	2	6	58	(b)		
	El Paso	20	5	0	2	0				
Utah:	Salt Lake City	24	1	0	0	3	11	3	11	1
Vt:	Barre	17	0	0	0	5	37	5	37	5
Va:	Richmond	15	1	0	0	5	59	5	59	5
Wash:	Seattle	7	0	0	0	5	35	(b)		
	Spokane	13	1	0	0	0				
W. Va:	Charleston	20	2	0	1	12	53	12	53	6
Wisc:	Madison	20	0	0	0	8	34	8	34	2
Wyo:	Cheyenne	10	1	0	1	0				
Network summary		903	8	0	0	145	61	4	58	3

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] February 1973

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Surface air and precipitation data for February 1973 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, February 1973

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	3	0.02	0.01	0.01	25	0.5
Coral Harbour	4	.02	.01	.02	27	.3
Edmonton	4	.03	.02	.03	18	.3
Ft. Churchill	3	.04	.03	.03	30	.2
Fredericton	4	.03	.02	.02	5	.5
Goose Bay	4	.02	.01	.02	6	.5
Halifax	4	.03	.01	.02	4	.5
Inuvik	4	.04	.03	.03	112	.5
Montreal	4	.03	.02	.02	9	.6
Moosonee	4	.04	.03	.04	27	.4
Ottawa	4	.03	.02	.03	NS	NS
Quebec	4	.02	.02	.02	6	.7
Regina	4	.03	.02	.02	23	.2
Resolute	4	.04	.03	.04	76	.1
St. John's, Nfld	3	.01	.01	.01	7	1.3
Saskatoon	4	.03	.02	.03	9	.2
Sault Ste. Marie	4	.03	.03	.03	7	.3
Thunder Bay	4	.03	.02	.03	10	.1
Toronto	4	.02	.01	.02	14	.7
Vancouver	4	.01	< .01	.01	12	.8
Whitehorse	4	.03	.01	.02	38	.2
Windsor	4	.02	.02	.02	11	.3
Winnipeg	4	.05	.02	.03	88	.6
Yellowknife	4	.03	.01	.03	25	.2
Network summary	93	0.05	< 0.01	0.02	26	0.4

NS, no sample.

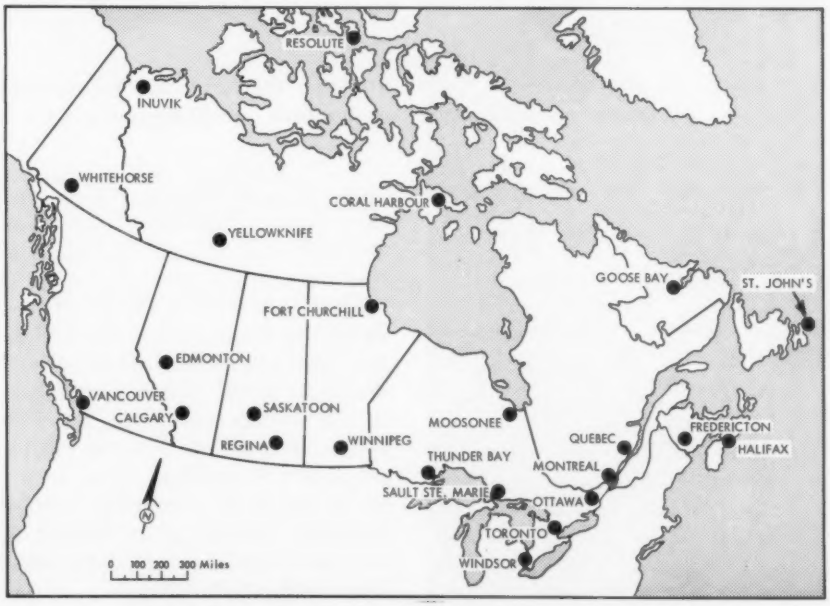

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program February 1973

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The February 1973 air monitoring results from the participating countries are given in table 3.

Table 3. Summary of gross beta radioactivity in Pan American surface air, February 1973

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	4	0.02	0.02	0.02
Bolivia:	La Paz	6	.02	.00	.01
Chile:	Santiago	26	.05	.01	.02
Colombia:	Bogota	20	.04	.00	.01
Ecuador:	Cuenca	8	.01	.00	.00
	Guayaquil	18	.03	.00	.01
	Quito	3	.01	.00	.00
Guyana:	Georgetown	9	.00	.00	.00
Jamaica:	Kingston	NS			
Peru:	Lima	NS			
Venezuela:	Caracas	12	.01	.00	.00
West Indies:	Trinidad	7	.03	.01	.01
Pan American summary		113	0.05	0.00	0.01

[a]The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

Figure 3. Pan American Air Sampling Program stations

4. California Air Sampling Program February 1973

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Airborne particles are collected by a continu-

Figure 4. California air sampling program stations

ous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic feet per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity, 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample for gamma spectroscopy and an analysis for strontium–89 and strontium–90. Table 4 presents the monthly gross beta radioactivity in air for February 1973. The monthly sample results are presented quarterly.

Table 4. Gross beta radioactivity in California air, February 1973

Station location	Number of samples	Gross beta radioactvity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	28	0.64	0.01	0.09
Barstow	28	.42	.00	.15
Berkeley	28	.17	.00	.04
Colfax	NS			
El Centro	25	.92	.02	.13
Eureka	28	.13	.00	.03
Fresno	28	.33	.01	.07
Los Angeles	27	.12	.00	.04
Redding	27	.09	.00	.04
Sacramento	28	.24	.00	.04
Salinas	28	.83	.00	.12
San Bernadino	28	.26	.01	.08
San Diego	27	.26	.01	.06
Santa Rosa	26	.12	.00	.05
Summary	356	0.92	0.00	0.07

NS, no sample.

5. Mexican Air Monitoring Program September-December 1972

Instituto Nacional de Energía Nuclear
México, D.F.

Until December 1971, the Radiation Surveillance Network of Mexico was operated by the Comision Nacional de Energía Nuclear (CNEN).

In December 1971, the CNEN became the Instituto Nacional de Energía Nuclear (INEN), as a result of a new law passed by Congress.

In the Instituto Nacional de Energía Nuclear, the Comité de Seguridad Radiológica (Radiological Security Committee) (CSR) is responsible for radiological protection. The Environmental Radioactivity Section (Sección de Radioactividad Ambiental) of the CSR is in charge of monitoring and measuring environmental radioactive contamination in general, including radiation in mines, uranium milling plant, and the Nuclear Center of Mexico.

Table 5. Mexican gross beta radioactivity of airborne particulates, September-December 1972

Station	Gross beta radioactivity (pCi/m³)			
	September	October	November	December
Chihuahua:				
Maximum	0.1	0.6	0.2	<0.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	.1	<.1	<.1
Ensenada:				
Maximum	.1	.2	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	(a)	.1	.1	(a)
Mérida:				
Maximum	<.1	.1	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	<.1	<.1	<.1
Mexico:				
Maximum	<.1	.5	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	.1	<.1	(a)
Torreón				
Maximum	.1	.7	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	<.1	<.1	<.1
Veracruz:				
Maximum	<.1	.1	.1	<.1
Minimum	<.1	<.1	<.1	<.1
Average	<.1	<.1	<.1	<.1

[a] Average not calculated for less than five samples.

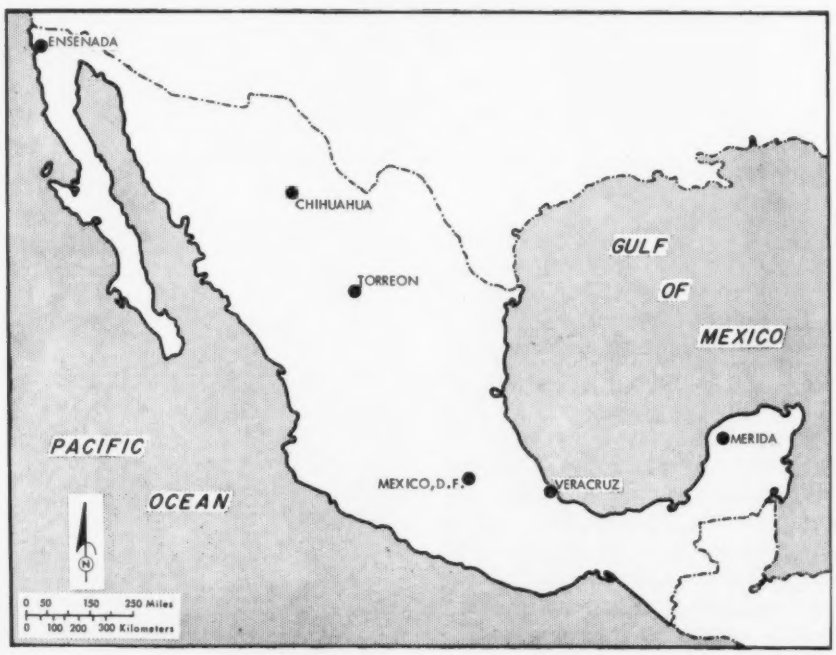

Figure 5. Mexican air sampling locations

Since radioactivity in air particulates have decreased to very low levels in the past few years, the objective of the air monitoring program has been changed from an alert type of network to emphasize dose assessment.

Measurements will continue in the following 6 areas: México City, D.F., Chihuahua, Ensenada, Torreón, Veracruz, and Mérida (figure 5). The sampling and analysis procedures were described previously (*6*).

The maximum, minimum, and average beta radioactivity in surface air from September through December are presented in table 5. Statistically it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*7*).

Table 6. Plutonium in airborne particulates October-December 1972

Location		Plutonium-238 (aCi/m³)	Plutonium-239 (aCi/m³)	$^{238}Pu/^{239}Pu$
Alaska:	Anchorage	1.9 ±0.5	15.4 ±3.3	8.1 ± 2.8
Ariz:	Phoenix	1.9 ± .6	24.7 ±2.8	13.0 ± 4.4
Colo:	Denver	1.1 ± .3	17.1 ±1.8	15.5 ± 4.9
Hawaii:	Honolulu	1.3 ± .4	9.2 ±1.2	7.1 ± 2.2
La:	New Orleans	1.2 ± .4	11.6 ±1.4	9.7 ± 3.4
Md:	Baltimore	.2 ± .1	7.7 ±1.2	38.5 ±11.3
N.Y:	Buffalo	1.5 ± .4	13.4 ±1.7	8.9 ± 2.6
N.C:	Gastonia	1.9 ± .5	10.9 ±1.3	5.7 ± 1.6
S. Dak:	Pierre	2.3 ± .5	9.6 ±1.2	4.2 ± 1.1
Tex:	Austin	1.4 ± .4	12.7 ±1.5	9.1 ± 2.8
Wash:	Seattle	.7 ± .2	13.4 ±1.8	19.1 ± 6.8

Other coverage in *Radiation Data and Reports:*

Period	Issue
October-December 1971	July 1972
January-March 1972	December 1972
April-September 1972	January 1973
July-September 1972	March 1973

6. Plutonium in Airborne Particulates October-December 1972

Office of Radiation Programs
Environmental Protection Agency

The Radiation Alert Network (RAN) of the Division of Atmospheric Surveillance, Environmental Protection Agency, routinely collects airborne particulate samples from 11 selected RAN stations for plutonium analyses. The plutonium analyses were initiated in November 1965, and references to the previous results through December 1969 have been published (*8*).

One-half of each individual air filter from the selected stations is sent to the Eastern Environmental Radiation Facility, Montgomery, Ala. The laboratory analyzes a composite of these samples from each station on a quarterly basis. The results from October to December 1972 are presented in table 6. The minimum detectable activities are 0.020 pCi and 0.015 pCi per sample for plutonium–238 and plutonium–239, respectively. The volume of air samples varies, generally ranging from 20,000 to 30,000 cubic meters per month.

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(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

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(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) INSTITUTO NACIONAL DE ENERGIA NUCLEAR. Mexican air monitoring program, August-December 1970 and January 1971. Radiol Health Data Rep 12:525–528 (October 1971).

(*7*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comision Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

(*8*) BUREAU OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April-December 1969. Radiol Health Data Rep 11:552–553 (October 1970).

Air Surveillance Network, February 1973

National Environmental Research Center—
Las Vegas,[1]
Environmental Protection Agency

The Air Surveillance Network[2] (ASN), operated by the National Environmental Research Center-Las Vegas (NERC–LV), consists of 49 active and 73 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing sponsored by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), by the Space Nuclear Systems Office at the Nuclear Rocket Development Station (which lies within the NTS), and by the AEC at any other designated testing sites.[2]

The stations are operated by State health department personnel and by private individuals on a contract basis. All active stations are operated continuously with filters being exchanged over periods generally ranging from 24 to 72 hours. All samples are mailed to the NERC–LV unless special retrieval is arranged at selected locations in response to known releases of radioactivity from the NTS. A complete description of sampling and analytical procedures was presented in the February 1972 issue of *Radiation Data and Reports.*

[1] Formerly the Western Environmental Research Laboratory.

[2] The ASN is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

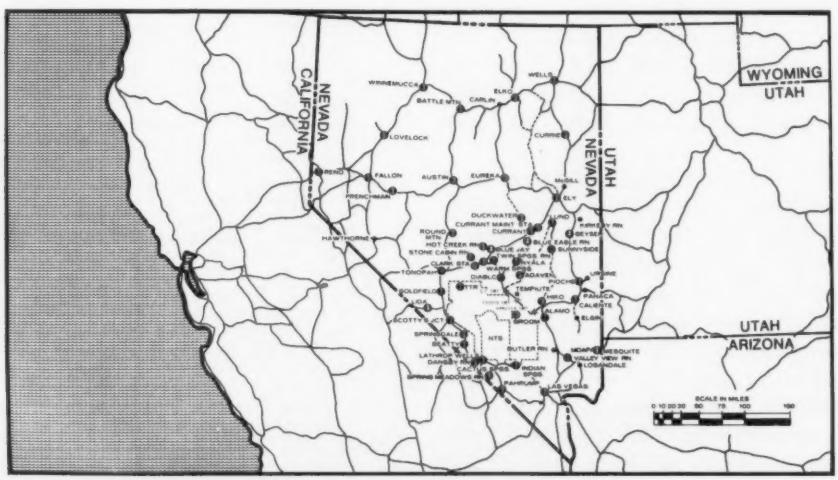

Figure 1. NERC-LV Air Surveillance Network stations in Nevada

Results

Table 1 presents the monthly average gross beta concentrations in air for each of the network stations. The highest gross beta concentration within the network was less than 0.2 pCi/m³ at Alamo and Round Mountain, Nev., and Delta, Utah. Because of low sample volumes (approximately 50 percent of normal) due to power outages at those three stations, the minimum detectable concentrations were 0.2 pCi/m³. The minimum reporting concentration for gross beta is 0.1 pCi/m³. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reporting level (0.1 pCi/m³) are reported as <0.1 pCi/m³. No radionuclides were identified by gamma spectrometry on any filters or charcoal cartridges during February 1973.

Complete copies of this summary and listings of the daily gross beta and gamma spectrometry results are distributed to EPA regional offices and appropriate State agencies. Additional copies of the daily results may be obtained from the NERC–LV upon written request.

Table 1. Summary of gross beta radioactivity concentrations in air, February 1973

Location		Number of samples	Concentration (pCi/m³)		
			Maximum	Minimum	Average [a]
Ariz:	Kingman	28	<0.1	<0.1	<0.1
	Seligman	28	<.1	<.1	<.1
Calif:	Baker	23	.1	<.1	<.1
	Barstow	28	<.1	<.1	<.1
	Bishop	28	<.1	<.1	<.1
	Death Valley Junction	28	<.1	<.1	<.1
	Furnace Creek	27	<.1	<.1	<.1
	Long Pine	24	<.1	<.1	<.1
	Needles	20	<.1	<.1	<.1
	Ridgecrest	28	<.1	<.1	<.1
	Shoshone	28	<.1	<.1	<.1
Nev:	Alamo	28	<.2	<.1	<.1
	Austin	24	<.1	<.1	<.1
	Beatty	26	<.1	<.1	<.1
	Blue Eagle Ranch (Currant)	28	<.1	<.1	<.1
	Blue Jay	28	<.1	<.1	<.1
	Caliente	28	<.1	<.1	<.1
	Currant Ranch	28	<.1	<.1	<.1
	Diablo	28	<.1	<.1	<.1
	Duckwater	27	<.1	<.1	<.1
	Ely	28	<.1	<.1	<.1
	Eureka	28	<.1	<.1	<.1
	Fallini's Twin Springs Ranch	28	<.1	<.1	<.1
	Geyser Maintenance Station	28	<.1	<.1	<.1
	Goldfield	28	<.1	<.1	<.1
	Groom Lake	19	.1	<.1	<.1
	Hiko	28	<.1	<.1	<.1
	Indian Springs	28	<.1	<.1	<.1
	Las Vegas	19	<.1	<.1	<.1
	Lathrop Wells	28	<.1	<.1	<.1
	Lida	28	<.1	<.1	<.1
	Lund	27	<.1	<.1	<.1
	Mesquite	28	<.1	<.1	<.1
	Nyala	28	<.1	<.1	<.1
	Pahrump	26	<.1	<.1	<.1
	Pioche	28	<.1	<.1	<.1
	Round Mountain	28	<.2	<.1	<.1
	Scotty's Junction	27	<.1	<.1	<.1
	Stone Cabin Ranch	28	<.1	<.1	<.1
	Sunnyside	20	<.1	<.1	<.1
	Tonopah	27	<.1	<.1	<.1
	Tonopah Test Range	21	<.1	<.1	<.1
	Warm Springs	28	<.1	<.1	<.1
	Warm Springs Ranch	28	<.1	<.1	<.1
Utah:	Cedar City	27	<.1	<.1	<.1
	Delta	28	<.2	<.1	<.1
	Garrison	28	<.1	<.1	<.1
	Milford	27	<.1	<.1	<.1
	St. George	28	<.1	<.1	<.1

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported a <0.1.

Figure 2. NERC-LV Air Surveillance Network stations outside Nevada

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

A summary of the environmental radioactivity data follow for the Knolls Atomic Power Laboratory.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Knolls Atomic Power Laboratory[2] January-December 1971

General Electric Company
Schenectady, N.Y.

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission (AEC), is to support the AEC in the development and testing of nuclear reactors for power plants. This includes design, construction, operation, and maintenance of prototype nuclear power reactors. The Knolls Atomic Power Laboratory consists of two sites, the Knolls and the Kesselring site, located as shown in figure 1.

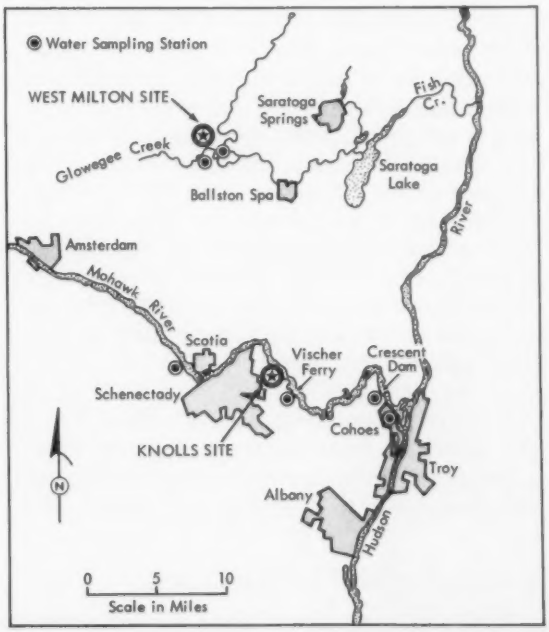

Figure 1. Environmental monitoring locations, KAPL

[2] Summarized from "Environmental Monitoring at Major U.S. Atomic Energy Commission, Knolls Site and Kesselring Site," January-December 1971.

Knolls site

The Knolls site is located 5 miles east of Schenectady, N.Y., on the south bank of the Mohawk River. It consists of approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radioactive materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings.

The Knolls site releases of radioactive materials both to the atmosphere and to the Mohawk River are limited to the lowest practicable amounts below the AEC standards. Prior to the release, exhaust air and liquid waste are treated and carefully monitored. In addition to the in-plant control monitoring, an environmental monitoring program is conducted to detect environmental trends related to Knolls site operations and to ascertain compliance with the radioactivity standards established by the AEC.

Air monitoring

Potentially radioactive exhaust air from Knolls site operations is filtered and monitored prior to discharge to the environment. Noble gases, according to detailed conservative analyses, result in an offsite exposure corresponding to less than 0.05 percent of the external radiation protection standard for an individual member of the offsite population. Continuous filter samples of the effluent are collected and these samples are analyzed on a weekly basis for gross alpha and beta-gamma activity and for selected radionuclides. Monitoring results for 1971 indicate a total discharge of 0.62 mCi consisting of 0.05 mCi of alpha particulate activity, 0.53 mCi of beta-gamma particulate activity and 0.04 mCi of iodine–131. During 1971, the radioactivity concentration in the effluent from the stacks averaged less than 3 percent of the appropriate environmental concentration guide for air as given in AEC Manual Chapter 0524.

Mohawk River and municipal waters

Continuous samples of Mohawk River water were collected at the General Electric Company powerhouse, 8 miles upriver from the Knolls site, and at the Vischer Ferry powerhouse, 1.7 miles downriver, as shown in figure 1. Weekly aliquots of each river sample were composited and analyzed on a monthly basis. In addition, grab samples of Schenectady municipal water were collected and analyzed. The samples were analyzed for gross alpha with alpha proportional counters and for gross beta-gamma activity using thin mica end-window geiger counters. In addition, municipal water was analyzed for strontium–90, if the gross beta-gamma concentration exceeded 10 pCi/liter; this did not occur during 1971. Each analysis involves radiation counting of dry mounts prepared by appropriate chemical procedures; i.e., an extraction technique for alpha analysis, an evaporation procedure employing nitric acid for beta-gamma analysis, and a separation procedure for strontium–90 analysis.

The radioactivity monitoring results for Mohawk River water and Schenectady municipal water for 1971 are summarized in table 1. The results show no statistical differences between the radioactivity concentration in river water upstream and downstream of the Knolls site or between river water samples and samples of municipal water. The gross beta-gamma radioactivity and the gross alpha radioactivity concentrations averaged less than 1.5 percent and 0.014 percent, respectively, of the applicable environmental concentration guide for water, as determined from AEC radiation protection standards. The data presented in table 1 and the foregoing comparison indicate that the small amount of radioactivity discharged during 1971 had no discernable effects on the environmental radioactivity levels in Mohawk River and municipal waters.

Mohawk River bottom sediment

The Knolls site Mohawk River sediment monitoring program involved the collection and analyses of sediment samples in each of three calendar quarters; ice coverage prevents collection during the first calendar quarter. Bottom samples were collected at the upriver and downriver locations from the Knolls site with a Birge-Ekman Dredge from areas 6 inches by 6

Table 1. Radioactivity in Mohawk River water and Schenectady municipal water, Knolls site, 1971 [a]

Location and source of water sampled	Number of samples	Total radioactivity concentration (pCi/liter)					
		Alpha			Beta-gamma		
		Maximum	Minimum	Average	Maximum	Minimum	Average
General Electric Powerhouse, 8 miles upriver	52	<1.1 (MDA)	<0.17 (MDA)	<0.65	6.3±4.4	<3.6 (MDA)	<4.7
Vischer Ferry, 1.7 miles downriver	52	<1.1 (MDA)	.26±.25	<.68	<5.0 (MDA)	<3.9 (MDA)	<4.6
Schenectady municipal water	11	<1.1	<.23 (MDA)	<.68	<4.9 (MDA)	4.0±3.6	<4.6

[a] Minimum detectable activity (MDA) values and the statistical precision (±) values are expressed at the 95-percent confidence level.

inches to an average depth of 1 inch. All samples were analyzed for gross alpha activity by the extraction technique, for gross beta-gamma by direct counting of a dried aliquot of the sample, and for gamma emitters by gamma spectrum analysis. Selected samples are also analyzed for strontium–90 by isotopic separation technique. The radioactivity monitoring results for Mohawk River bottom sediment for 1971 are summarized in table 2.

The data presented in table 2 indicate that the radioactivity concentration in sediment downriver from the Knolls site is generally higher than the concentration upriver. This resulted from liquid effluent releases prior to 1964, when the activity discharged per year was up to 7,000 times higher than in recent years. Of the total radioactivity released from the Knolls site, over 99 percent was discharged prior to 1964.

Perimeter monitoring

Environmental monitoring thermoluminescent dosimeters are posted on the Knolls site security fence. The results of this monitoring show that the general public did not receive radiation exposure greater than natural background as a result of Knolls site operations.

Kesselring site

The Kesselring site, located on approximately 3,900 acres near West Milton, N.Y., is a part of the Knolls Atomic Power Laboratory. Its

Table 2. Radioactivity concentrations in Mohawk River sediment,[a] Knolls site, 1971

Area sampled relative to effluent point	Number of samples	Total radioactivity (pCi/g wet weight)					
		Alpha			Beta		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Upriver	6	0.39±0.10	0.14±0.07	0.25±0.06	26±5.7	12±4.9	19±3.0
Downriver	36	.69± .15	.12± .06	.33± .05	31±5.5	9±4.8	17±3.0
Opposite	3	.31± .08	.28± .08	.29± .05	20±5.0	14±5.1	17±3.0
		Cesium-137 (pCi/g wet weight)			Strontium-90 (pCi/g wet weight)		
Upriver	3	.96± .68	[b] ≤.44	≤.62± .32	[b] ≤.23	[b] ≤.21	≤.22± .18
Downriver	3	3.1 ± .94	[b] ≤.29	≤.94± .33	.40±.27	[b] ≤.21	≤.27± .15
Opposite	3	1.4 ± .65	[b] ≤.45	≤.80± .33	[b] ≤.21	[b] ≤.21	≤.21± .14

[a] Multiply values by 2.3 to convert to units of pCi/g (dry weight).
[b] Minimum detectable activity values and the statistical precision (±) values are expressed at the 95-percent confidence level.

principal facilities include the S3G and D1G prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Water monitoring

All Glowegee Creek water analysis results were below the minimum detectable activity concentration that may be considered valid at the 90-percent confidence level. During the report period, a new analytical technique lowered the minimum detectable activity from 50 pCi/liter to 4.5 pCi/liter with a maximum error of ± 100 percent at the 90-percent confidence level. The results show no statistically significant difference between the radioactivity concentration in Glowegee Creek water upstream and downstream from the site.

Sediment monitoring

Glowegee Creek sediment radioactivity measurements are analyzed by gamma radiation spectrometry on a monthly basis. Sample locations are the same as those listed for Glowegee Creek water sampling. The minimum detectable activity (MDA) for cobalt–60 is 0.1 pCi/g of sediment while the MDA for the gross gamma radioactivity analysis is 0.2 pCi/g of sediment. These MDA's are based on average height and density values of sediment samples obtained using a 90-percent confidence level for the error. The samples are taken by scooping up 2 inches of sediment from the creek bottom. At least 500 grams are required for each sample. Table 3 presents the sediment analysis results.

The results show no statistically significant difference between the radioactivity concentration in Glowegee Creek sediment upstream and downstream from the site.

Table 3. Radioactivity in Glowegee Creek sediment Kesselring site, January–December 1971

Location	Number of samples	Gross gamma radioactivity[a] (pCi/g dry weight)		Cobalt–60 (pCi/g dry weight)
		Average	Range	Average
Upstream	9	13.0	9.1-16.9	1.9
Downstream	10	14.3	8.8-19.4	2.0

[a]Primarily potassium–40.

Environmental radiation monitoring

In addition to the air exhaust stack radioactivity monitoring, surveys are made semiannually of the radiation levels at the Kesselring site perimeter. Perimeter surveys performed during the year showed normal background radiation levels for the geographic location. The result of the perimeter survey extrapolated to an annual exposure indicates average perimeter radiation levels of <0.1 roentgen per year. It is concluded that Kesselring site operations did not significantly contribute to the natural background radiation of the surrounding area.

Effluent monitoring

Liquid effluent released from the Kesselring site is collected, processed, and sampled prior to release to the Glowegee Creek. During discharge each retention basin is sampled when one half of the liquid is discharged and again just prior to completion. The water returned to the Glowegee Creek in 1971 contained less than 0.92 mCi of radioactivity. This results in an average concentration of less than 0.006 percent of the appropriate AEC standards.

Air released from power plant and radiological support buildings is continuously monitored for air particulate activity. The activity is collected on high efficiency filter paper and the activity is analyzed for beta-gamma activity. The total airborne particulate radioactivity discharged to the environment during the calendar year 1971 was less than 2 pCi. This resulted in an average concentration of less than 1.5 percent of the appropriate AEC standard. The only gaseous radionuclide of concern, argon–41, has a half life of less than 2 hours and does not build-up in the environment.

It is concluded from the effluent monitoring results that Kesselring site operations are effective in protecting the environment and the public health.

Recent coverage in *Radiation Data and Reports:*

Period	Issue
January-December 1970	January 1973

Nuclear Power Reactors in the United States
March 31, 1973

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of *Radiation Data and Reports.*

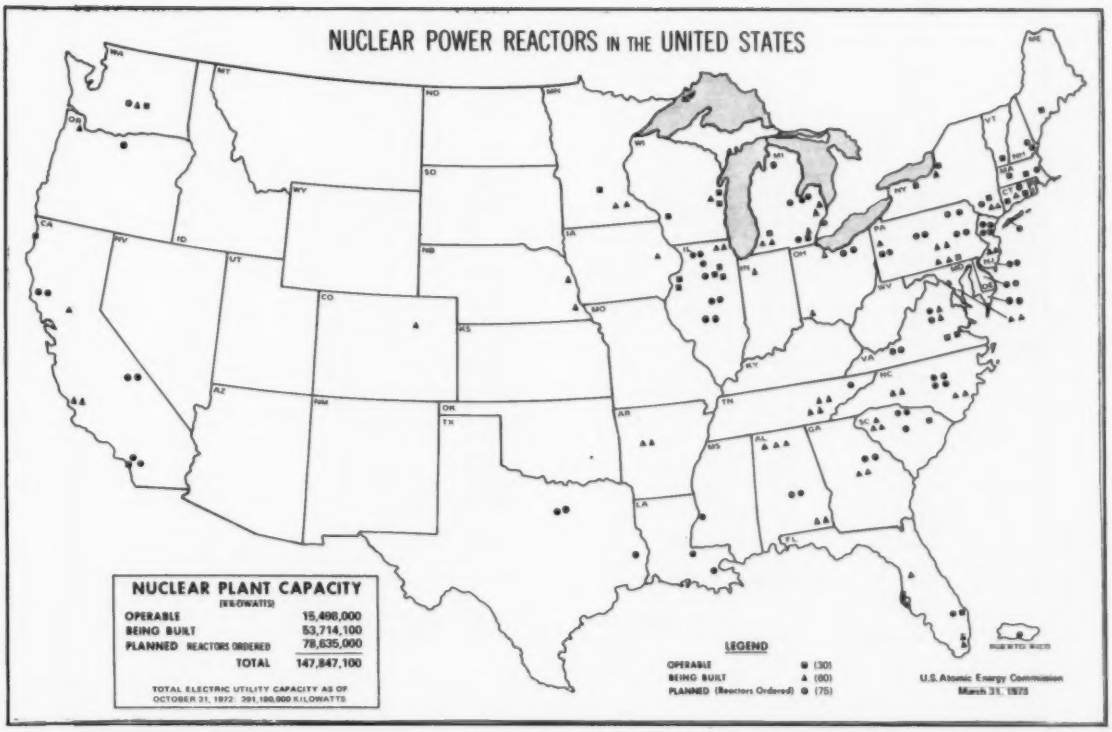

Figure 1. Nuclear power reactors in the United States, March 31, 1973

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1974
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1974
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
Selma	Orville: Unit 1	1,100,000	Alabama Power Co.	1981
Selma	Orville: Unit 2	1,100,000	Alabama Power Co.	1982
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	902,000	Arkansas Power & Light Co.	1976
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	–
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	–
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generating Station	804,000	Sacramento Municipal Utility District	1974
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1979
"	–	770,000	Southern California Edison Co.	1981
"	–	770,000	Southern California Edison Co.	1982
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1973
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
Waterford	Millstone Nuclear Power Station: Unit 3	1,150,000	Northeast Utilities	1979
DELAWARE				
Middletown	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1978
Middletown	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1981
FLORIDA				
Florida City	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1972
Florida City	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1973
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Ft. Pierce	St. Lucie Plant: Unit 1	801,000	Florida Power & Light Co.	1975
Ft. Pierce	St. Lucie Plant: Unit 2	801,000	Florida Power & Light Co.	1979
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	795,000	Georgia Power Co.	1976
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 1	1,121,000	Georgia Power Co.	1978
Waynesboro	Alvin W. Vogtle, Jr. Plant: Unit 2	1,121,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Cordova	Quad-Cities Station: Unit 2	800,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1977
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1978
Byron	Byron Station: Unit 1	1,120,000	Comm. Edison Co.	1979
Byron	Byron Station: Unit 2	1,120,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 1	1,100,000	Comm. Edison Co.	1980
Braidwood	Braidwood: Unit 2	1,100,000	Comm. Edison Co.	1981
Clinton	Clinton Nuclear Power Plant	950,000	Comm. Edison Co.	1980
Clinton	Clinton Nuclear Power Plant	950,000	Comm. Edison Co.	1982-3
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1977
IOWA				
Palo	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station	1,165,000	Louisiana Power & Light Co.	1976
St. Francisville	River Bend Station	934,000	Gulf States Utilities Co.	1979

Figure 1. Nuclear power reactors in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1974
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
Douglas Point	Douglas Point Project: Unit 1	1,178,000	Potomac Electric Power Co.	1980
Douglas Point	Douglas Point Project: Unit 2	1,178,000	Potomac Electric Power Co.	1981
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station: Unit 1	664,000	Boston Edison Co.	1972
Plymouth	Pilgrim Station: Unit 2	1,180,000	Boston Edison Co.	1978
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1976
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 3	1,125,000	Detroit Edison Co.	1980
Bridgman	Donald C. Cook Plant: Unit 1	1,060,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1977
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1978
St. Clair County	Greenwood: Unit 2	1,240,000	Detroit Edison Co.	1979
St. Clair County	Greenwood: Unit 3	1,240,000	Detroit Edison Co.	1981
Quanicassee	Quanicassee: Unit 1	1,150,000	Consumers Power Co.	1981
Quanicassee	Quanicassee: Unit 2	1,150,000	Consumers Power Co.	1981
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1973
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
MISSISSIPPI				
Port Gibson	Grand Gulf Nuclear Station	1,290,000	Mississippi Power & Light Co.	1978
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973
NEW HAMPSHIRE				
Seabrook	–	1,100,000	Public Service of N.H.	1979
Seabrook	–	1,100,000	Public Service of N.H.	1981
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	640,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,070,000	Jersey Central Power & Light Co.	1978
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N.J.	1974
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N.J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,067,000	Public Service Electric and Gas, N.J.	1978
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,067,000	Public Service Electric and Gas, N.J.	1979
Little Egg Inlet	Atlantic Generating Station: Unit 1	1,150,000	Public Service Electric and Gas, N.J.	1980
Little Egg Inlet	Atlantic Generating Station: Unit 2	1,150,000	Public Service Electric and Gas, N.J.	1981
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1973
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1974
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,080,000	Niagara Mohawk Power Co.	1978
Ontario	R.E.Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N.Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980

Figure 1. Nuclear power reactors in the United States—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	906,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Painesville	Perry Nuclear Power Plant: Unit 1	1,100,000	Cleveland Electric Illuminating Co.	1979
Painesville	Perry Nuclear Power Plant: Unit 2	1,100,000	Cleveland Electric Illuminating Co.	1980
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1976
OREGON				
Prescott	Trojan Nuclear Plant: Unit 1	1,130,000	Portland General Electric Co.	1975
Boardman		1,200,000	Portland General Electric Co.	1980
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1978
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1979
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	852,000	Duquesne Light Co.-Ohio Edison Co.	1974
Shippingport	Beaver Valley Power Station: Unit 2	852,000	Duquesne Light Co.-Ohio Edison Co.	1978
Goldsboro	Three Mile Island Nuclear Station: Unit 1	819,000	Metropolitan Edison Co.	1973
Goldsboro	Three Mile Island Nuclear Station: Unit 2	905,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1979
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1981
*	Philadelphia Electric Co.: HTGR No. 1	1,140,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co.: HTGR No. 2	1,140,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S.E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1973
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Broad River	Virgil C. Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
Lake Wylie	Catawba Nuclear Station: Unit 1	1,180,000	Duke Power Co.	1979
Lake Wylie	Catawba Nuclear Station: Unit 2	1,180,000	Duke Power Co.	1980
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,140,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,140,000	Tennessee Valley Authority	1975
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1977
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1978
Oak Ridge	Fast Breeder Demonstration Plant	400,000	Tennessee Valley Authority	1980
TEXAS				
Glen Rose	Commanche Peak Steam Electric Station: Unit 1	1,150,000	Texas Power & Light Co.	1980
Glen Rose	Commanche Peak Steam Electric Station: Unit 2	1,150,000	Texas Power & Light Co.	1982
Newton County	Blue Hills: Unit 1	950,000	Gulf States Utilities	1980
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1972
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1973
Mineral	North Anna Power Station: Unit 1	898,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	898,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
*	–	900,000	Virginia Electric & Power Company	1980
*	–	900,000	Virginia Electric & Power Company	1981
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	WPPSS No. 1	1,120,000	Washington Public Power Supply System	1980
Richland	WPPSS No. 2	1,103,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	53,200	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1972
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Michigan Power Co.	1972
PUERTO RICO				
Puerto De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975
*	–	1,189,000	Tennessee Valley Authority	1977
*	–	1,189,000	Tennessee Valley Authority	1978
*	–	1,120,000	Tennessee Valley Authority	1980
*	–	1,120,000	Tennessee Valley Authority	1981
*	–	1,120,000	Tennessee Valley Authority	1981
*	–	1,120,000	Tennessee Valley Authority	1982

* Site not selected.

Figure 1. Nuclear power reactors in the United States—continued

Reported Nuclear Detonations, May 1973

(Includes seismic signals presumably from foreign nuclear detonations)

There were no nuclear detonations reported for the United States by the U.S. Atomic Energy Commission for May 1973.

Not all of the nuclear detonations in the United States are announced immediately, therefore, the information in this section may not be complete. A complete list of announced U.S. nuclear detonations may be obtained upon request from the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

SUMMARY OF ENVIRONMENTAL MONITORING AT PHILADELPHIA, 1958–1971. *J. E. Lieberman, R. D. Ice, M. Green,* and *R. McGrattan, Radiation Data and Reports, Vol.* 14, June 1973, pp. 333–350.

The City of Philadelphia maintains an environmental radiation surveillance program for evaluating the environment of the Delaware Valley. The program has evolved from the initial goals of setting operational guides for the collection and analyses of data at sites of nuclear ship operations, through preoperational radiological data collection associated with the construction of the N.S. Savannah, through a nuclear weapons fallout evaluation to the present objective of providing environmental surveillance of nuclear facilities.

A 13-year compilation of environmental data from the City of Philadelphia is presented. Included are gross alpha and gross beta results of raw and finished surface waters, gross beta results of air samples, and strontium–90, and iodine–131 quantities in pasteurized milk.

KEYWORDS: Air, barium–140, Chinese and French bomb tests, gross alpha, gross beta, iodine–131, lanthanide, milk, N.S. *Savannah,* Philadelphia, Pa., radioactivity, strontium–89, strontium–90, water, yttrium.

JOINT DENTAL RADIATION SURVEY IN PUERTO RICO, 1968. *Michael Gileadi. Radiation Data and Reports, Vol.* 14, June 1973. pp. 351–355.

The objective, scope, and methods used in the 1968 Joint Dental Survey Project, sponsored jointly by the Health Department of Puerto Rico, Puerto Rico Nuclear Center and School of Dentistry, University of Puerto Rico, are described. Health hazards associated with dental x-ray diagnostic procedures in Puerto Rico 1968 are evaluated, and relevant statistical and technical data pertinent to the use of x rays in the dental profession on the Island are presented.

KEYWORDS: Dental, x rays, Puerto Rico

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